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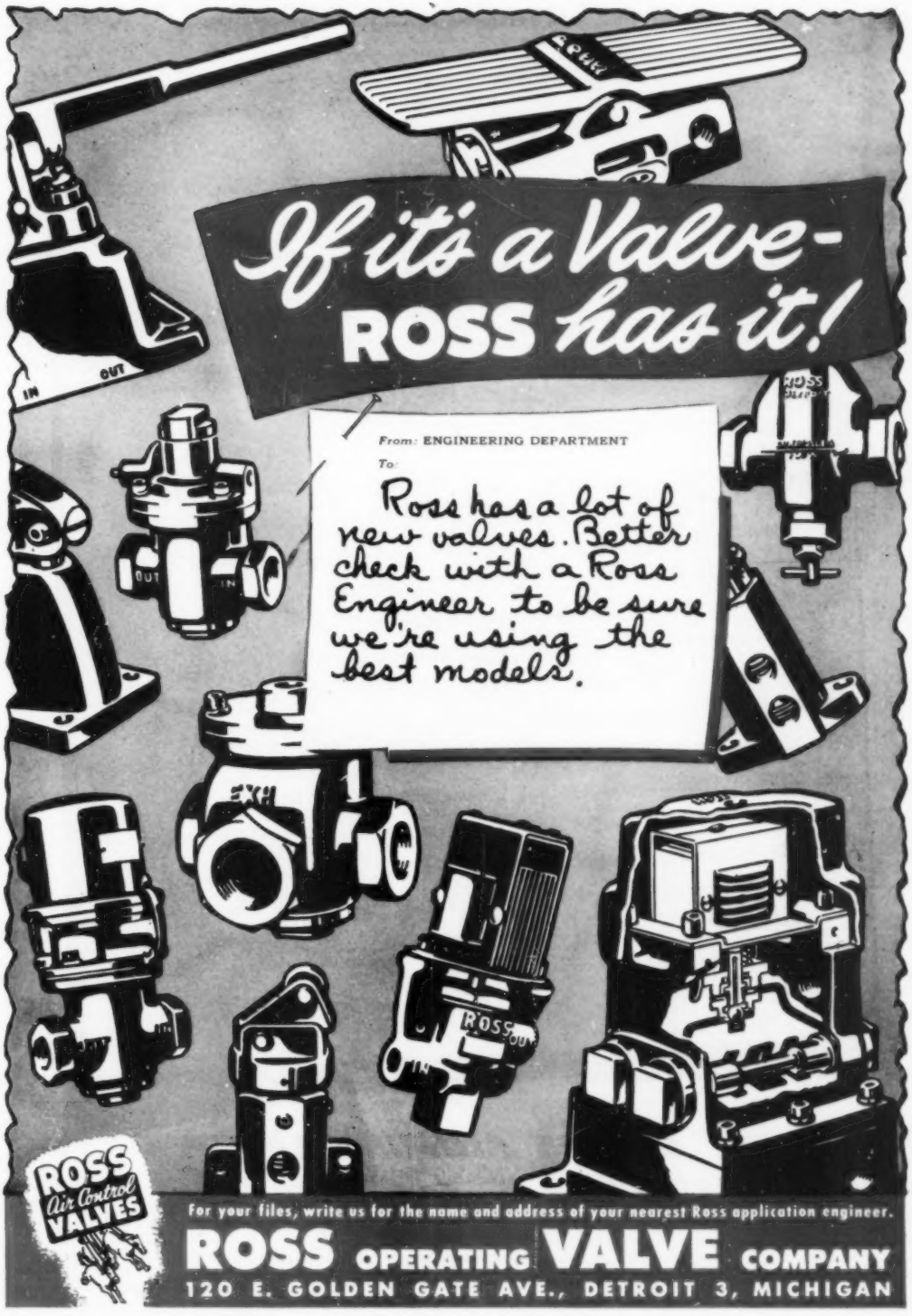
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TO USERS OF ALUMINUM PRODUCTS

THE CONTROLLED MATERIALS PLAN

AND YOUR ALUMINUM NEEDS

MILLIONS OF POUNDS OF ALUMINUM FLOWING INTO DEFENSE PROGRAM AT RATES THAT LEAVE LITTLE FOR OTHER USES. TO GUARD AGAINST SPECIFICATION OF DEFENSE PRODUCTS EARLIER AND IN GREATER AMOUNTS THAN NECESSARY TO HANDLE INCREASING VOLUME IN ORDERLY MANNER THE D.O. PRIORITY SYSTEM TO BE SUPERSEDED BY BROADER PROGRAM. THE CONTROLLED MATERIALS PLAN DESIGNED TO DISTRIBUTE THIS AVAILABLE METAL ON EQUITABLE BASIS AND DIRECT IT TO NEEDED USES. CMP IS SCHEDULED TO START IN JULY AND WILL UNDOUBTEDLY BE FULLY EFFECTIVE IN FOURTH QUARTER. DURING TRANSITION FROM D.O. TO CMP MANY INSTRUCTIONS WILL BE ISSUED AND MUST BE STUDIED BY ALL PRODUCERS AND USERS OF ALUMINUM, COPPER AND STEEL. FOR THIS REASON IT IS IMPORTANT TO KEEP IN CONTACT WITH REVERE SALES REPRESENTATIVES. IN FACT FOR UP-TO-THE-MINUTE NEWS ON ALUMINUM ALWAYS KEEP IN TOUCH WITH REVERE. REVERE COPPER AND BRASS INCORPORATED, ALUMINUM DIVISION.

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NUMBER 6

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JUNE 1951

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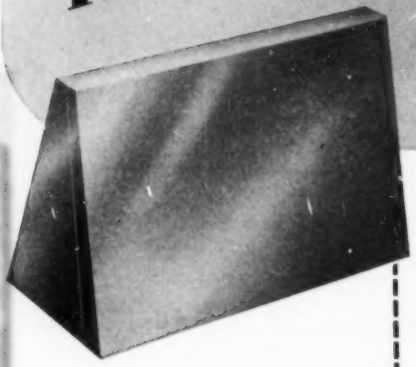
Service Beyond The Sale!



Less Weight, Less Space, Better Job . . . with Mallory High-Density Alloy

The products of Mallory metallurgical pioneering have had far-reaching effects in reducing costs and improving designs for Mallory customers. One notable contribution is Mallory 1000, a high-density, machinable alloy with a great variety of applications.

In the aviation industry, the use of lead or brass for aileron counterweights has been an obstacle to designers intent on making airfoils smaller and thinner. The substitution of Mallory 1000, with its higher density, provides equal weight in less space. And because the smaller unit can be moved further from the fulcrum, it is possible to reduce its weight as well. Finally, because of its greater mechanical strength, Mallory 1000 can be drilled and tapped for direct attachment to the balance arm, eliminating the intermediate mounting required by the lead weight. Thus Mallory 1000 does the job, with less weight and cube, permitting improved design and greater payloads!

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Mallory 1000 has a density one and a half times greater than lead. It has great strength and is readily machinable. Its resistance to the corrosive action of many acids, as well as the atmosphere, is excellent.

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Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

NONMETALLIC MATERIALS

GLASS TUBES work better than steel wires as supports for plaster cores used in the investment casting of aluminum alloy radar tube-feed units. Tubes are lubricated with graphite and mounted to permit longitudinal expansion.

SPHERCIAL GRAINS OF SILICA a millionth of an inch in diameter apparently do a better job of maintaining the desired consistency of greases than do the commonly-used soaps. Grains of the GS-100S material are treated to make them float on water, thus preventing separation.

ALL-COLOR WOOD may find a ready market in some consumer products such as television cabinets. Wood plies are impregnated with formulations of various tints and laminated into sheets containing as many as eight plies. One or more layers are then routed out, thus exposing the different colors in a variety of patterns.

LAMINATED PHENOLIC PLATES, sliced edgewise to give an end-grain surface, are fastened to the slides of the column base, vertical slide and spindle head of a Pratt & Whitney milling machine. These liners prevent scoring and wear of bed ways and maintain accuracy of parts.

A CERAMAL COATING containing 80 percent by weight of chromium and 20 percent frit permits extended operation of turbine blades at temperature of 1,800 F. Coating is fired to an 80 percent titanium carbide--20 percent cobalt blade at 2,200 F for 10 min in an atmosphere of hydrogen.

"UNPAINTABLE" SURFACES, at least those subject to high temperatures, will be practically nonexistent now that a special gloss-finish composition is available. Makers claim the paint is stable at 1,900 F, as well as moisture and acid resistant. Applied by conventional methods, material comes in aluminum, black and white.

RUBBER AND CURLED HAIR have such good cushioning properties that together they are being used for packing delicate instruments. Combined material can be molded to fit a given application.

FELT-LIKE PAPER containing sub-microscopic asbestos fibers does a real job of filtering. Pleated sheets of the paper are reported to remove all but a few of the 20,000 particles of dust from a cubic inch of the atmosphere.

METALLIC MATERIALS

75S ALUMINUM ALLOY now has a competitor which carries the temporary ALCOA designation XA 78S. Of the same general composition as 75S (Al-Zn-Cu-Mg), new alloy is about 10 percent higher in tensile and yield strengths and has similar elongation and fatigue properties. Some sacrifice in workability is involved. Current production of sheet and plate in both bare and clad forms is on a "pilot-plant" basis.

SPRING ALLOY used in aircraft-type pressure indicator is unusually stable throughout temperature range from -67 to +158 F. Called Iso-Elastic, the Ni-Cr-Mo alloy has a thermoelastic coefficient of -20×10^{-6} /deg F to $+15 \times 10^{-6}$/deg F, a hysteresis error of less than 0.05 percent of deflection and a creep error of not more than 0.02 percent of deflection in five minutes.

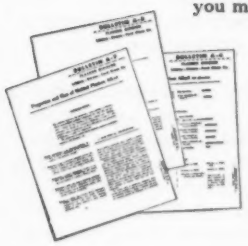
THREE EMISSION BANDS are produced from a phosphor composed of arsenic and zinc sulfide. As one of many materials used for converting invisible radiations to visible light, this phosphor can be adapted through variations in the arsenic content, firing atmosphere, and temperature of excitation to give a wide range of effects.

HIGHER YIELD STRENGTHS are predicted for titanium alloys in the very near future. Through refinements in manufacturing techniques, existing compositions will be good for 180,000 to 200,000 psi. And some of the problems in ma-

(continued on page 7)

Changing to Plaskon Alkyd Molding Compound enabled Barber-Colman Company to cut the cost of molding these magneto rotors for J. I. Case tractors *in half* . . . "a 50% saving". And J. I. Case credits Plaskon Alkyd for satisfactory mechanical and electrical properties, with complete absence of objectionable electrical "tracking" across the rotors.

Applications of many types offer convincing proof that quick-curing Plaskon Alkyd can usually be molded *three to four times faster* than conventional thermosetting materials. This means that dies with fewer cavities may be used to achieve a given production rate. And because Plaskon Alkyd can be molded at lower pressures, maintenance of tools and presses is generally reduced. There are *so many ways to save* using Plaskon Alkyd for the molding of plastic parts! We will be glad to tell you more whenever it is convenient for you to see one of us.



Your files should contain these bulletins on the properties, uses, and molding of Plaskon Alkyd Molding Compounds. Write and we will send your free copy by return mail.

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PLASKON® ALKYD

chining tatanium are well on the way to being solved, thus bringing closer the day when the wonder metal will play a vital role in the emergency program.

EXTENSIVE TESTS on a series of zirconium alloys reveal that various elements raise the physical properties as compared to commercially pure metal, but at some reduction in corrosion resistance. Al, Ti and Ta up the strengths, but aluminum makes the metal harder to work.

SINTERED WROUGHT MOLYBDENUM of high purity shows promise of great importance in the defense program. Tests at NACA reveal tensile strenghts of almost 34,000 psi at 1,800 F and 27,500 at 2,400 F. Proper working and handling of the metal during fabrication appear to be the factors that require particular attention.

ELECTRO STEELS containing no Co, Cb, Ti or Zi and small amount of Ni have yield strength of 75,000 psi and ultimate of 95,300 psi in fully annealed condition. Elongation is 49 percent and reduction of area is 64.5 percent. Alloys are corrosion resistant and weldable; are austenitic in structure and non-magnetic.

COMPONENTS

IF STORAGE BATTERIES are again in short supply, sales of the Mobil 210 unit should be brisk. By reducing the amount of acid in the cells, the life of the battery is extended some 14 percent. Result is lower capacity during early stages of operation, but longer overall life at a full-charge specific gravity reading of 1260.

ANCHOR NUTS and gang channel nuts of new design will interest airframe makers because of their reduced weight. Anchor plate nut is 25 percent lighter and the gang nut 30 percent less heavy than current designs. Trick is the removal of excess metal without sacrificing the strength.

ELECTRICAL TERMINALS used in applications where gases and fluids are present can be sealed with Termin O Seals. Made of neoprene or silicone rubber to bracket the temperature range from -67 to +500 F, these rings are compressed into a square section and allowed to expand into position, thus sealing the joint. Special studs and insulators are supplied with the seals.

FOUR NEEDLE BEARINGS contribute largely to the compactness and operating efficiency of a high-pressure gear pump. Combined tolerances of about 0.001 in. for the bearing housing and body bore permit continuous operation at 2,000 psi and intermittent use at 3,000 lb per sq inch.

MERCURY PLUNGER RELAY has three sets of hermetically-sealed tungsten contacts, all of which operate from a single coil. Simultaneous open and /or closing is thus obtained and long service life assured. A-c loads up to 35 a/110v or 25 a/220v per contact can be handled.

DELAYED-ACTION LIGHT SWITCH has a spring-loaded neoprene diaphragm that operates in an evacuated aluminum chamber. After the toggle arm is pushed to the "delay" position, diaphragm holds circuit closed for 60 sec, permitting operator to leave room before light goes out.

PROCESSES

BETTER RESISTANCE WELDS in aluminum alloys are obtainable through electronic control of single phase a-c equipment during the first few cycles. Lengthening the time during which the welding current flows compensates for reduced heat input to weld. Electrode contact area is thus increased and sticking prevented.

THREE ORGANIC AGENTS are used in a nickel brightener process for covering tool marks and other blemishes in metallic surfaces. Primary brightening agent is a powder, the secondary agent a liquid for producing a specular effect, and the wetting agent a paste for controlling pitting. Process is adaptable to buffed brass, steel and copper; cold-rolled steel and die-castings.

FLUID FITTINGS such as valves made of AISI type 300 austenitic steel have the following properties when finished by a new electrolytic process: A chemically pure surface free of embedded metal and foreign matter, deburred edges and threads, stress relieved structure and greatly increased corrosion resistance.

SOME CAR MAKERS are considering a process for applying chromium directly to steel. Preserved with a coating of lacquer, the bright finish lacks the abrasive resistance of nickel-

(continued on page 9)

Deep-Drawn Shapes

with improved strength-weight ratios

produced by the

Scaife

Reverse-Draw Process

Deep-Drawn Shapes made by Scaife have exceptionally high strength-weight ratios, because the Reverse-Draw Process has the inherent property of maintaining a uniform wall thickness throughout the entire length of draw. The result is a superior deep-drawn shape, suitable for pressure vessels and containers, housings of various types, rocket and missile bodies and many other parts or enclosures. We will be glad to receive your inquiries regarding shapes up to 36-inches in diameter, with wall thicknesses up to ¼-inch, formed by this process, from ferrous and non-ferrous metals.

The illustrations show a few of the shapes that can be produced by the Scaife Reverse-Draw Process.

Scaife Company

Founded 1802

OAKMONT (Pittsburgh District) PA.

or copper- chromium, but still is rust and corrosion resistant and pleasing in appearance.

HOT DIMPLING of high-strength 75ST aluminum alloy has proven most successful when a conduction heating method is used. Temperature control is obtained through the use of a heating element placed in the dimpling tool as a backup for the die. Work hardening is minimized, thus forming the metal without reducing its ductility.

METAL-TO-RUBBER BONDING by an electroplate method is the basis of a recently issued patent, No. 2,551,342. Rubber is first treated with a solution of phosphorous trichloride and, after drying, given a coating of electrically-conductive graphite.

PNEUMATIC GAGING has been adapted to controlling the thickness of rubberized cord fabric as it is calendered. Measuring head consists of two opposing jets, one above and one below the material. As tacky mass passes between the jets, variations in its thickness change the pressure in the head. The magnified pressure is then used to regulate the speed of the machine.

TESTING

VERSATILE RECORDER plots voltage and current readings continuously on an eight-inch circular chart. Unit is adaptable for wall, surface panel and portable uses with either open terminal or conduit connections. Magnetic damping along with special shock-resisting and locking devices, plus a measuring circuit that gives high actuating torque at low power are design features.

MOISTURE METER can be used on most any material--wood, rubber, plaster--that will accommodate electrode probes. Instrument functions on the resistance principle and has two scales with overall range from 2,000 ohms to 20,000 megohms. Specially calibrated scales for specific materials are under development.

A PERMANENT MAGNET mounted on the end of a rotary switch shaft simplifies the use of a stroboscope when comparing the relative speeds of rotating members. With the lamp beam directed at a reference mark on one member, the magnet is pushed against the end of the second member. Coupling action of the magnet causes switch to rotate and flash the lamp.

LEAK DETECTOR for determining extremely small leaks in vacuum systems utilizes hot platinum that emits positive ions in increased quantities when stimulated by freon gas or other halogens. If a jet of freon directed against a test spot strikes a leak, a needle on the meter deflects in proportion to magnitude of the leak.

PORTABLE INSTRUMENT measures the thickness of non-ferrous layers on ferrous bases. Magnetic reluctometer can be used as a comparator or limit gage as well as for giving absolute thickness values. Unit has three separate ranges, 0-5, 0-10 and 0-30 thousands of an inch.

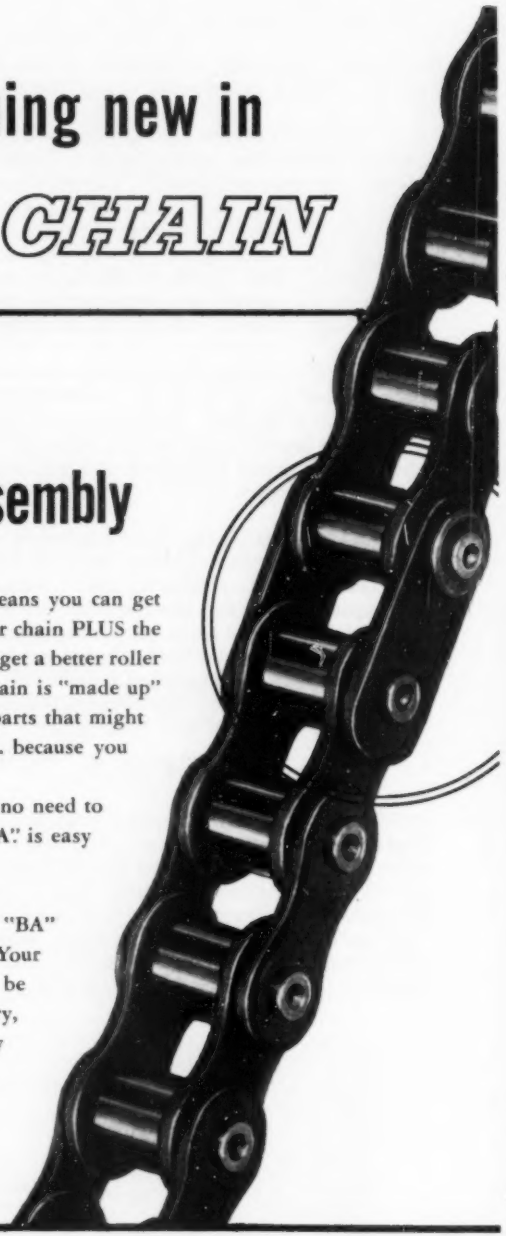
"FREE-FLIGHT" CONDITIONS are being simulated in a wind tunnel used for testing models of the flexible-wing B-47. Attached to a rod running from ceiling to floor, model has full freedom to move. "Pilot" controls the wing surfaces through remotely controlled motor mounted in the model.

THIS MONTH'S COVER

Electric switches of the types used to turn power on and off are usually fairly large components which are not designed for precision or repeatability. For units built into small packages, the field of use immediately broadens to include new functions and functions for which large units are not particularly well adapted. Such is the case with precision, snap-acting electric switches, several types of which made by the MICRO SWITCH Division of Minneapolis-Honeywell Regulator Company are pictured on this month's cover. As many as several thousand different types, sizes, and ratings are available from various companies in the field. For details on selection and application, see article starting on page 162. Kodachrome by Hans Basken, McGraw-Hill Studios.

there IS something new in ROLLER CHAIN

the revolutionary Baldwin-Rex "BA" Assembly



TO YOU... This great new development means you can get the strength, long life and lower cost of riveted roller chain PLUS the easy assembly and disassembly of cottered chain. You get a better roller chain, *first* because it's riveted—*second* because the chain is "made up" to size, not "cut up" with possible damage to chain parts that might weaken it. You'll save because it's lower in cost . . . because you waste no chain through damage in cutting.

You can reduce your inventory materially. There's no need to order long lengths and cut them as needed. And "BA" is easy to order . . . easy to stock.

TO YOUR CUSTOMERS... With "BA" on your machines, you're offering a better product. Your customers like the ease with which "BA" Chains can be coupled and uncoupled. If a replacement is necessary, it's easy with "BA". They'll like the longer life they get with Baldwin-Rex "BA" Riveted Chain. They can even replace a small worn section of drive quickly and easily.

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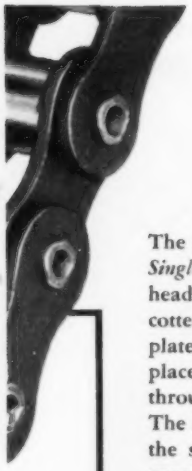
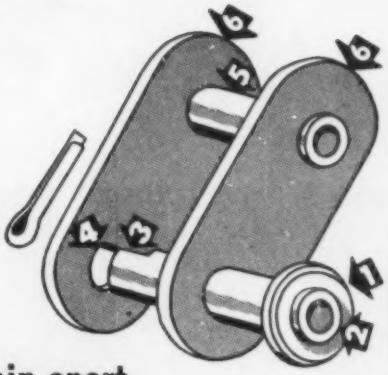


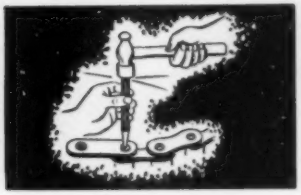
here's the "BA" secret!

The secret of the Baldwin-Rex "BA" Assembly is the *Single Pin* Connector. A washer (1) is spun over the head of the connector pin (2). The milled flat (3) at the cottered end of the pin fits into a special hole in the side plate (4). This combination holds the pin firmly in place, yet it's easy to remove because it's a "sliding fit" through the entire link except for the milled flat end. The riveted pin at the other end of the link (5) holds the side plates (6) firmly in place when single pin connector pin is removed.

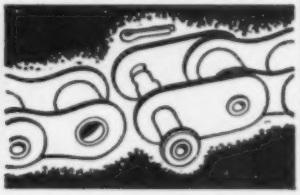


look how easy it is to take this chain apart

Locate the single pin connector link in the strand. It's easily identified by its distinctive shape.



Next, remove the cotter and drive the milled flat end of the pin out of the special hole in the side plate. It will slide out easily. No danger of destroying chain parts or damaging fits.



There it is—that's all there is to it. The chain is apart in a matter of seconds. It's as simple as that. And assembly is just as easy.

any length of chain you want . . . *when you want it!*

Baldwin-Rex "BA" Assembly Chain is shipped in standard 5-foot lengths—two lengths to a box. From these 2 units plus the standard "BA" short units, you can build up any length you want from one link to 10 feet. Or, if you prefer, you can order pre-assembled lengths in quantity. In either case, you're getting "made up" chain—not "cut up" chain.

For the complete story on "BA", simply mail the coupon.

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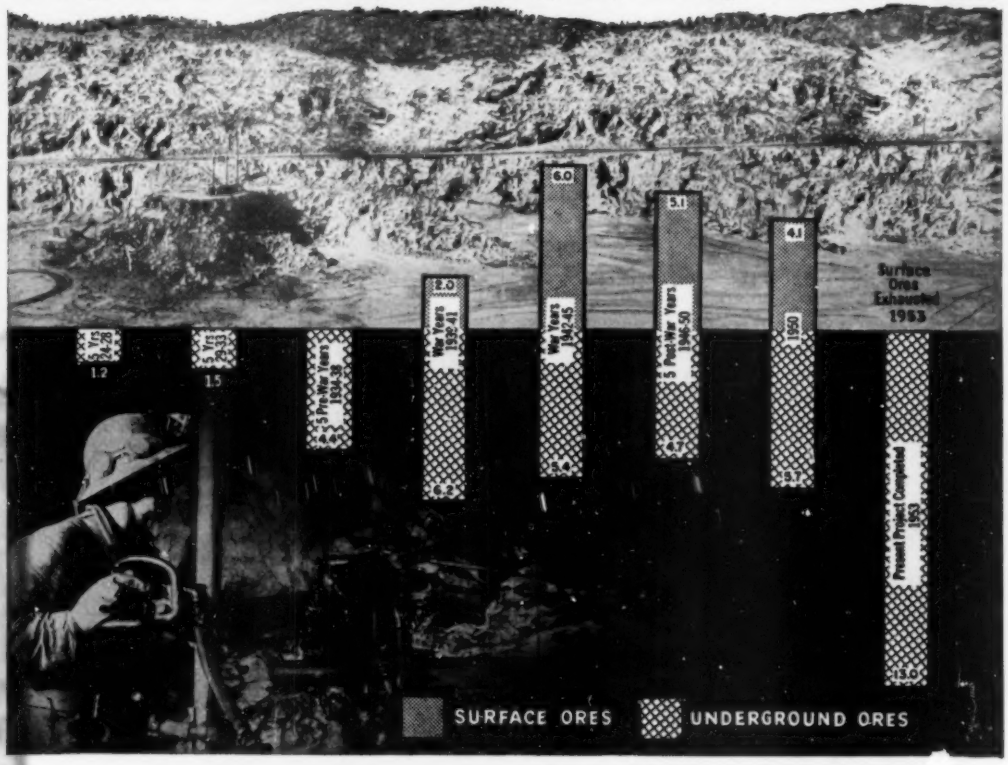
City.....*State*.....

Underground and surface ORE MINED (yearly average—millions of tons)



Underground for Defense

...started more than 10 years ago

STRENGTH...military and economic ...depends on productivity. And productivity depends on men who have devoted long years to their specialized chosen field of endeavour.

Such men with "know-how" mine nickel from the rocky rim of Ontario's Sudbury Basin ...

By increasing output with maximum speed and drawing on reserve stocks of nickel previously accumulated, they helped raise deliveries of nickel in all forms during 1950 to 256,000,000 pounds ... a record for any peace-time year.

This record, 22% greater than the 209,292,257 pounds delivered in 1949, was no accident ...

In 1937, INCO launched a vast long-range project which now makes it possible to meet the military requirements of the United States, Canada and the United Kingdom. In addition, nickel deliveries are being made to government stockpiles and the balance of the supply is being rationed among civilian consumers in all markets throughout the free world.

Since the inception of International Nickel, its fixed policy has always been to increase the supply of nickel. To meet today's needs, INCO went underground years ago.

Anticipating the eventual depletion of Frood-Stobie open pit surface ores, more than 10 years ago, INCO embarked on a program of replacing open pit with underground capacity. This required extensive enlargement of underground plants, development of new methods of mining not previously undertaken and the revamping of metallurgical processes to cope with difficulties in recovering nickel from the new types and lower grades of ores which have to be reached.

Major expansion in output of nickel from underground operations is being driven to conclusion with utmost speed. There is still much construction to be done and a number of mining and metallurgical problems remain to be solved and tested in actual operation. Barring unforeseen interruptions, full conversion to underground mining should be completed in 1953.

When the present undertaking is completed, INCO will be able to hoist 13,000,000 tons annually, and the size of its underground mining operation will surpass that of any other non-ferrous base metal mining operation in the world.

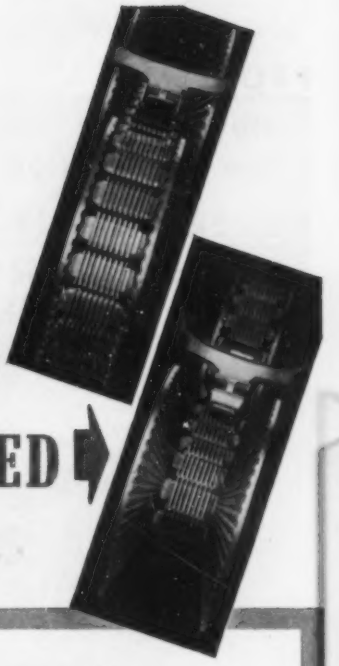
This underground expansion is being completed by INCO without interrupting current production of nickel, which is at maximum capacity.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Only the P.I.V. variable speed drive has tooth-grip action . . . from

MAXIMUM SPEED to MINIMUM SPEED

with an infinite number of positive settings



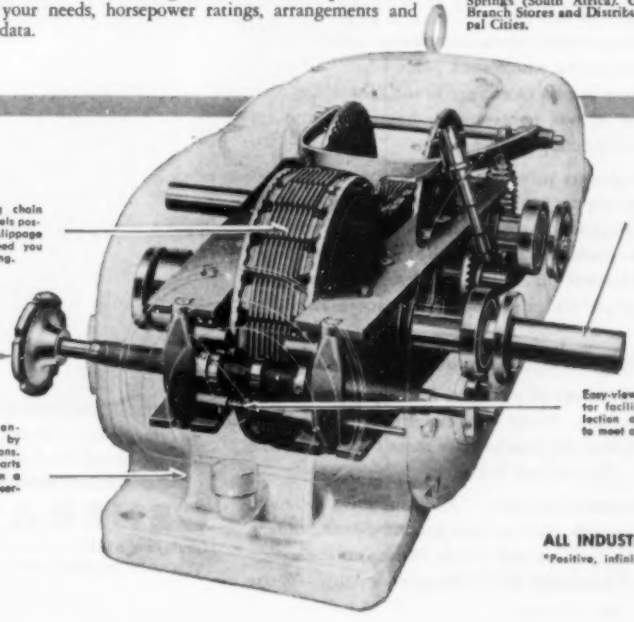
Only Link-Belt's P.I.V. delivers *positive*, stepless speed changing independent of friction . . . because only Link-Belt's P.I.V. has the self-tooth-forming chain that makes this possible. Your nearest Link-Belt branch office can show you how to increase the efficiency and flexibility of your machines, and supply complete information —covering pre-selection of the right P.I.V. variable speed transmission for your needs, horsepower ratings, arrangements and engineering data.

LINK-BELT

P.I.V. VARIABLE SPEED DRIVE

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in Principal Cities.

12,205



Self-tooth-forming chain grips toothed wheels positively without slippage — gives the speed you need at any setting.

You can get minute speed changes and maintain them accurately while operating under full load.

An infinite number of positive, stepless speed adjustments may be made with manual, electric, pneumatic or hydraulic controls.

Easy-view speed indicator facilitates speed selection and adjustments to meet all requirements.

All-metal, totally enclosed — unaffected by atmospheric conditions. All vital operating parts splash-lubricated from a common housing reservoir.

ALL INDUSTRY USES P.I.V.*

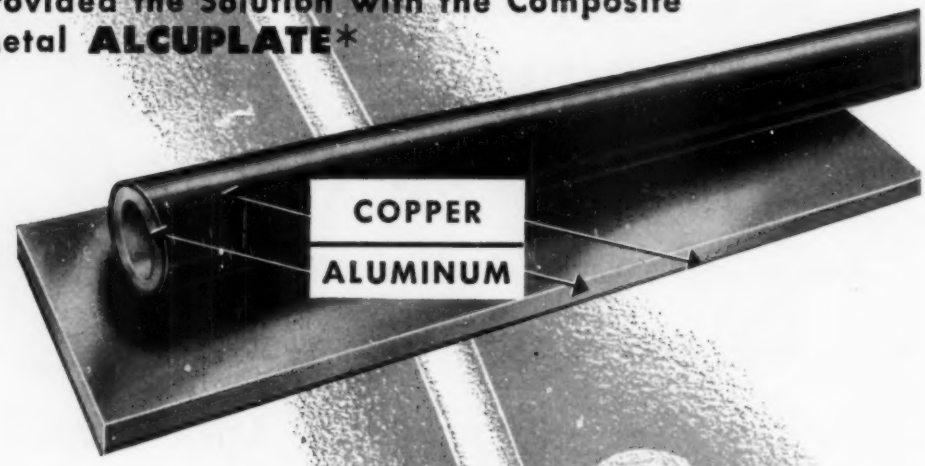
*Positive, infinitely variable

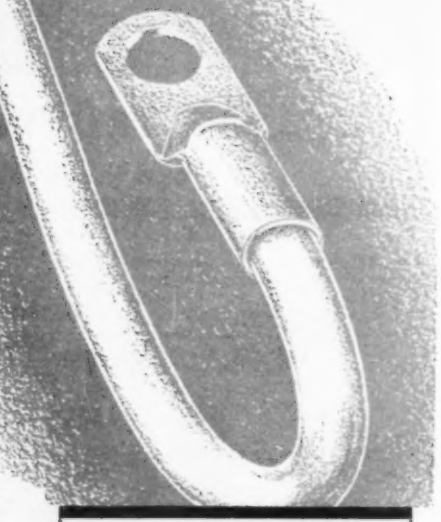
PROBLEM:

How to Get "Aluminum-to-Aluminum" Connections in the Termination of Aluminum Conductors

GENERAL PLATE:

Provided the Solution with the Composite Metal ALCUPLATE*





Aircraft manufacturers and power companies were troubled with the electrolytic action which took place when aluminum main line cables were joined to copper branch lines. To overcome this problem it was necessary to have aluminum-to-aluminum or copper-to-copper connections.

General Plate engineers solved the problem with *Alcuplate* (aluminum clad to copper) which gives like metal connections, thus overcoming the corrosion objections. Alcuplate is widely used in the electrical field for clips, shims, bushings, terminals, etc. Enclosures for sealed devices can be spun or drawn from *Alcuplate* and the copper surface makes soft soldering easy.

Alcuplate is available in sheet, strip or seamless tubing.

No matter what your metal problem, it will pay you to consult with General Plate. Their vast experience in cladding precious to base metals or base to base metals can overcome your problems . . . often reduce costs.

General Plate Products include . . . Precious metals clad to base metals, Base metals clad to base metals, Silver Solders, Composite contacts, buttons and rivets, Platinum fabrication and refining, Age-hardenable #720 Manganese Alloy. Write for information. *Reg. U. S. Pat. Off.

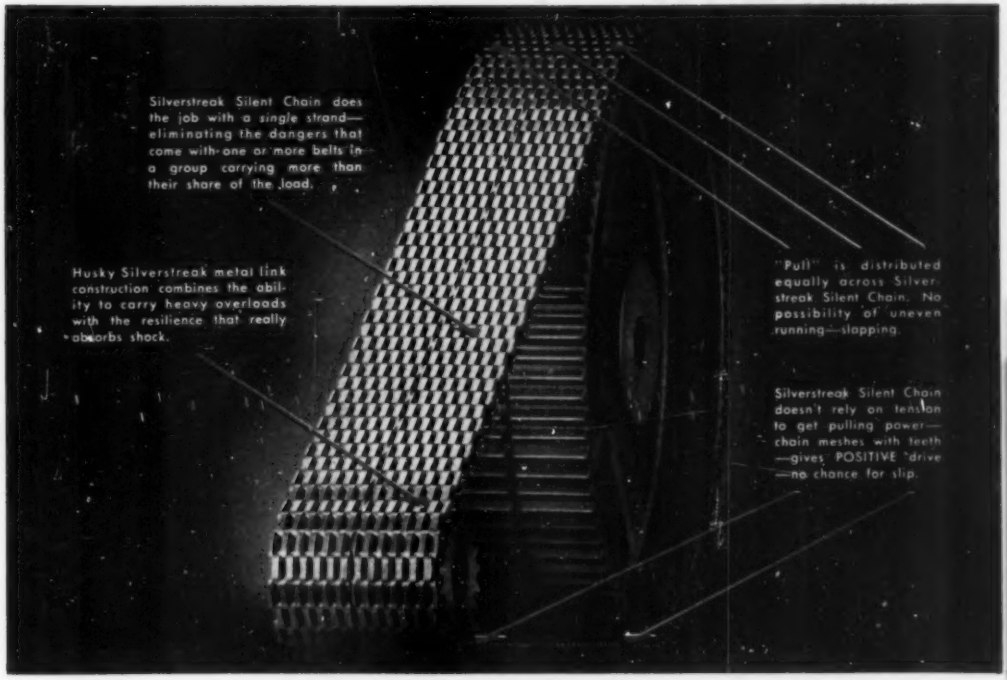
Have You a Composite Metal Problem? General Plate can solve it for you

GENERAL PLATE

Division of Metals & Controls Corporation

106 FOREST STREET, ATTLEBORO, MASS.

Get full rpm transmission...


Silverstreak Silent Chain does the job with a single strand—eliminating the dangers that come with one or more belts in a group carrying more than their share of the load.
Husky Silverstreak metal link construction combines the ability to carry heavy overloads with the resilience that really absorbs shock.
"Pull" is distributed equally across Silverstreak Silent Chain. No possibility of uneven running—slapping.
Silverstreak Silent Chain doesn't rely on tension to get pulling power—chain meshes with teeth—gives POSITIVE drive—no chance for slip.

LINK-BELT Silverstreak Silent Chain Drives

Slip-proof
Slap-proof
Shock-proof

TAKE the proven road to increased production — through the best in high-speed power transmission. You'll find Link-Belt Silverstreak Silent Chain Drives are 98.2% efficient. With normal maintenance, you have a *positive* drive that runs for years and years.

And note this important point — on extremely short centers Silverstreaks lose none of their efficiency. What's more, reduction ratios as high as 10-to-1 are frequently used. Both of these Silverstreak features save you valuable space.

One test will prove to you why thousands of production-minded engineers have standardized on Link-Belt Silverstreak Silent Chain Drives.

LINK-BELT

12,200

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in principal cities.

Keeping Nearly 17 Tons in Check!

TDA BRAKES

PROVIDE POSITIVE BRAKING—POSITIVE CONTROL!

Safety is an important consideration in *any* construction operation! That's why dependable TDA Brakes were used on the Cleveland Electric Illuminating Company's specially-built pavement cutter. This unusual machine is used to cut pavement preparatory to trenching operations for underground cables and steam mains. Two slots approximately 2 inches wide and up to 17 inches deep can be cut as fast as five feet per minute! A TDA Duo-Grip Brake is used for emergency purposes and to hold the machine on grades. Simple construction and positive action decrease maintenance—increase performance!

WHATEVER *YOUR* BRAKING PROBLEM— TAKE IT TO TDA BRAKE DIVISION!

In this modern age of power and speed, manufacturers have to rely more and more on safe, effective brakes to keep their machines under constant control. And TDA Brakes are filling this need consistently and dependably—even under the most unusual and exacting requirements! These advance-designed brakes are the result of TDA's more than 40 years of braking experience—plus the efforts of highly competent technicians and engineers. If you have a braking problem—regardless of its nature and scope—contact TDA Brake Division! By simply mailing the coupon below you'll find out how you and your product will be repaid.

Here Are A Few Of The Many Products Which Can Be Equipped With TDA Brakes

Centrifuges • Compressors • Conveyors • Cranes Cream Separators • Diesel hook-ups • Dry cleaning machinery • Extractors • Hoists • Industrial electric trucks • Lathes (automatic) • Looms (textile) • Lumber mill machinery • Machine tools • Materials handling equipment • Motors • Packaging machinery • Paint mixers • Press brakes • Printing presses • Rolling mills • Shears • Warpers (textile) • Welding positioners • Winches • Automotive • Farm equipment Earth moving equipment • Construction equipment Public transportation.

IF IT ROTATES WE CAN BRAKE IT

TDA BRAKE DIVISION—DEPT. A-3
ASHTABULA, OHIO

Please mail brake information on these applications.

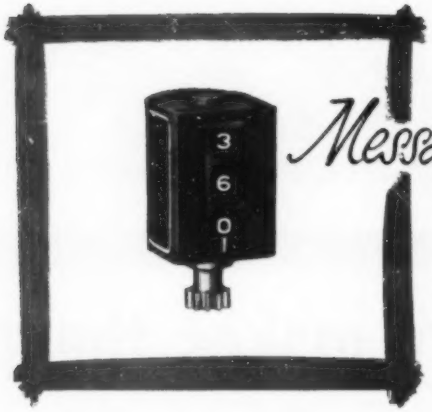
NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

TIMKEN Detroit BRAKES
TDA BRAKE DIVISION
THE TIMKEN-DETROIT AXLE COMPANY
ASHTABULA, OHIO.
Accepted SAE Standard
TRADE MARK REGISTERED



Messages or Missiles...
...the men who dispatch them count on Veeder-Root...
...in fact...

Everyone Can Count on VEEDER-ROOT

Radar, communications, gunfire *Countrol*... and many other military "musts"...count on Veeder-Root Counters for dependable, continuous Facts-in-Figures. Never mind how. Just count on it that the job is being done... right up "to the nines."

If *anything* is worth keeping track of, then you can count on Veeder-Root to do the job as it needs to be done...within the limitations of defense production, of course.

VEEDER-ROOT INC.
HARTFORD 2, CONN. • GREENVILLE, S. C.
Montreal, Canada Dundee, Scotland
Offices and agents in principal cities

VEEDER-ROOT COUNTERS *"Count Everything on Earth"*

Designer's

Simplified design makes them easier to install and service!

No doubt about it! Simplified design, for faster, easier installation and maintenance, has made these General Electric magnetic contactors—heart of the whole G-E line of starters— a big hit with machinery manufacturers. For instance:

- Terminals, easily accessible from the front, have large pan-head or slotted hex-head screws to speed wiring of either stranded or solid wire.
- Main poles in the three smaller sizes—and interlocks in all sizes—can be changed from normally open to normally closed without need of extra parts, facilitating quick changes and reducing your inventory of "specials."
- Extra two-circuit interlocks—with interchangeable normally open or normally closed contacts—can be quickly added to either side of contactor, need no drilling, no extra accessories.
- Arc hood is held in place by two easily-removed captive screws to expose terminals completely for inspection and maintenance.
- Three-point keyhole slots in rear of contactor make panel mounting a simple matter, and insulated aluminum base permits mounting on all types of panels.
- NEMA mounting dimensions mean maximum interchangeability.

Your G-E representative, or authorized G-E agent or distributor, can supply you all NEMA sizes for a-c motors up to 50 hp. Meanwhile, get the full story in Bulletin GEA-5154.

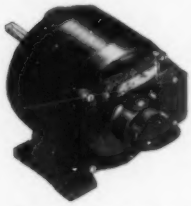
MAGNETIC CONTACTORS

SIZE 00 SIZE 0 SIZE 1 SIZE 2 SIZE 3

GENERAL ELECTRIC

Digest — GE PRODUCT HIGHLIGHTS

A FULL LINE OF FHP MOTORS TO MEET YOUR NEEDS



Fhp machine-tool motor

This polyphase induction motor, specifically designed for frequent start-stop duty on machine tools, is one of a wide variety of G-E standardized fractional-hp motors available to meet your design needs. This complete line includes, for general applications, polyphase induction, d-c, capacitor-start, and split-phase motors, as well as gear and unit-bearing motors and a broad selection of definite-purpose motors for more limited applications. Specify one of these G-E motors in your next design. They're known to be preferred by your customers, play a big part in selling your product. See Bulletin GEA-5174.

SPEED, ACCURACY AND FLEXIBILITY —ALL IN ONE!

Photoelectric recorder

Besides measuring a-c and d-c volts and amperes, this versatile General Electric photoelectric recorder provides a quick, accurate record of almost anything that can be measured with an indicating instrument—temperature, speed, pressure, thickness, light, and vibration. In deflection and potentiometer types, for portable use or semi-flush mounting, it features chart speeds from ½ inch to 72 inches per minute, sensitivities as low as 1.0 microampere full scale, and response periods as fast as ⅕ second for full-scale deflection. See Bulletin GEC-254.

HOW TO SIMPLIFY "BUILDING-IN" THE RIGHT SPEEDS

Adjustable-speed manual

This 26-page illustrated manual—a worthwhile addition to your reference file—covers the entire subject of adjustable-speed drives, including their economic and engineering benefits and the points to consider in their selection. Especially helpful is a concise description of available General Electric *packaged* adjustable-speed drives, plus a well-organized table that summarizes the ratings and performance features of each drive. See Bulletin GEA-5334.

NOW—MOTOR SELECTION AND APPLICATION SIMPLIFIED

NEW G-E "SHOW-HOW" COURSE helps train your workers

Of special interest to designers is this new General Electric Motor Selection and Application Course—timed to meet today's need for more motor "know-how" by your personnel. A G-E More Power to America program, it shows simply and clearly how motors work, types now in use, how to select and apply them to specific jobs. Kit includes instructor's manual, nine slidefilms with records, student review booklets, and sturdy carrying case. Ask your G-E representative for a free copy of the manual. Meanwhile send for Bulletin GEA-4938-16 describing the course in detail.

General Electric Company, Section C 668-89
Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ for reference purpose
- ☐ in connection with immediate projects

- ☐ **GEA-4938-16 Motor selection and application**
- ☐ **GEA-5154 A-c magnetic contactors**
- ☐ **GEA-5174 Fractional-hp motors**
- ☐ **GEA-5334 Adjustable-speed manual**
- ☐ **GEC-254 Photoelectric recorder**

CONSULT YOUR McGRAW-HILL ELECTRICAL CATALOG FOR PRODUCT ENGINEERS! You'll find "everything electric" for machinery manufacturers in the General Electric section.

NAME _____

COMPANY _____

STREET _____

CITY _____ STATE _____

Simple Arithmetic

Doehler Die-Casting

50 Years Experience

- ACCURACY
- DENSITY
- QUALITY CONTROL
- EXPERT ENGINEERING
- SURFACE FINISH
- DEPENDABILITY

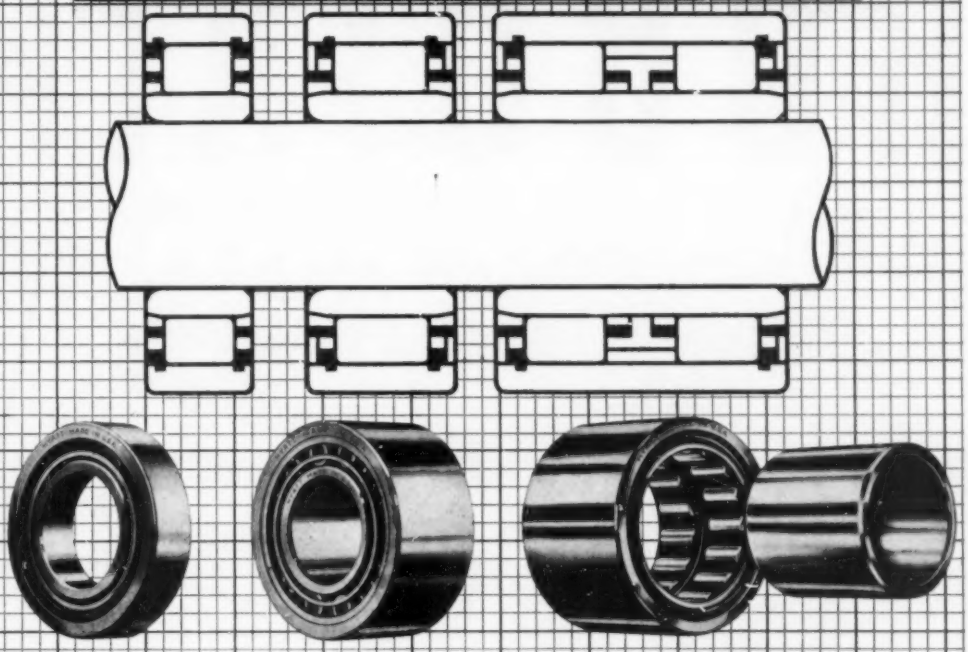
Jarvis Finish

25 Years Experience

- APPEARANCE
- ARTISTIC DESIGN
- PLATING ENGINEERING
- LONG LIFE
- RELIABILITY
- QUALITY CONTROL

Result:

For Greater Bearing Capacity—
HYATT HY-LOADS



A-1200-TS
Narrow Series

A-5200-TS
Wide Series

A-6200-TS
Duplex Series

Where bearing overall dimensions must be kept to a minimum, Hyatt Hy-Load Light Series Roller Bearings are available in three widths to satisfy load requirements and permit wide design range.

As greater load-carrying capacity or longer bearing life is required for a given shaft size and bore diameter, you can go progressively from the narrow, to the wide, or to the duplex series of Hyatt Hy-Load Bearings as illustrated.

When operating speeds are relatively low, greater radial capacity can be obtained in limited space with Hyatt Hy-Loads of the full complement type. In this type of bearing, available in both wide and narrow widths, the roller separators are eliminated, and the maximum number of rollers are employed to provide increased capacity within the same boundary dimensions.

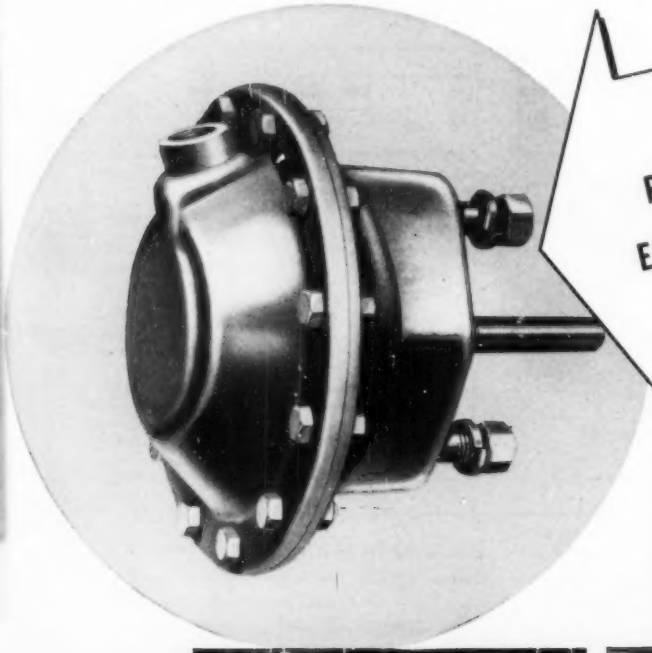
Write for a copy of catalog 547 . . . a complete guide to the selection and use of radial roller bearings. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

Modernize Even Your Latest Machine Tool Operations with

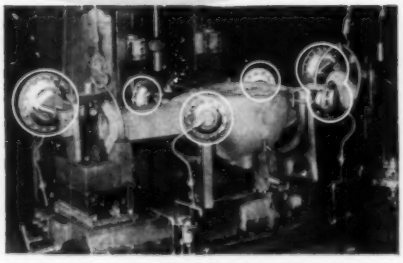
ROBOTAIR

THE INDUSTRIAL AIR CONTROL OF A THOUSAND USES



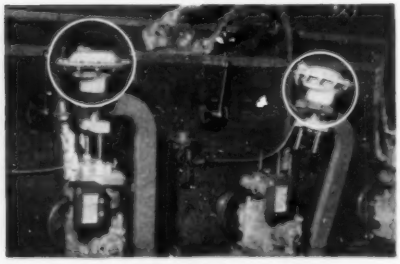
THIS SIMPLE, RUGGED, LOW COST, EASILY INSTALLED UNIT DOES THE JOB

A rugged air chamber that may be used wherever a short, powerful stroke is needed for holding, positioning or clamping. Produced in six different sizes with strokes from 1¾ inches to 3 inches. Also available is a smaller diameter ROTOCHAMBER which provides an even longer stroke with a similar pressure output. Your present air supply will be adequate for either, but compressors are available if needed.



SAVES MONEY

Savings realized on this operation for manufacturing axle housings by replacing hand screws and clamps with Robotair Chambers have *amounted to hundreds of dollars.*



CUTS HANDLING TIME

Before installation of Robotair on this compressor run-in test line, compressors were held in position by manually operated clamps. Simple adaptation of Robotair Chambers and two-way valves *cut handling time in half.*

...AND STEP UP YOUR PRODUCTION AS MUCH AS 30% WITHOUT ADDING MANPOWER

Amazing Savings in Time, Money and Effort

Bendix-Westinghouse, world's largest source of air brakes and other air devices, put more than a quarter century of experience behind the development and perfection of Robotair Industrial Controls. With their wide range of applications, these air controls now offer progressive manufacturers amazing improvements in production speed and economy at an *unbelievably low initial cost.* Ideal for holding, clamping, bending, swedging, staking, riveting, and compactly designed for easy installation on space limited machinery, Robotair Controls inevitably bring about lower manufacturing costs per unit through increased productivity of man and machine. Rugged, frictionless, leak-proof construction positively eliminates need of oilers and filters and assures millions of strokes at *100% efficiency for total life.* Low cost Robotair units are available as original equipment for machinery manufacturers or for installation on present shop equipment. To find out how Robotair can improve your production picture, send for your copy of the colorful Robotair booklet. Coupon at bottom of page.

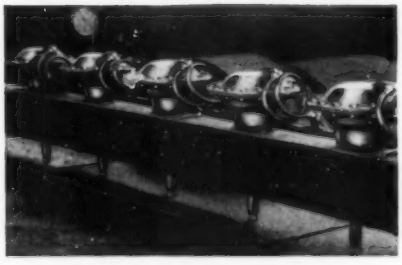
Industrial Distributors in All Major Cities.

Bendix-Westinghouse

BENDIX-WESTINGHOUSE AUTOMOTIVE AIR BRAKE COMPANY • ELYRIA, OHIO

BENDIX-WESTINGHOUSE ROBOTAIR

REG. U.S. PAT. OFF.



REDUCES OPERATOR FATIGUE

Various sizes of steel plates are held in position by series of Robotair Chambers in this end grinding operation. Use of Robotair eliminated battery of hold down bolts and clamps, greatly reducing operator fatigue.

BENDIX-WESTINGHOUSE
Automotive Air Brake Co.
Elyria, Ohio Dept. A

Please send me your free booklet on "Robotair—the Industrial Air Control of a Thousand Uses."

NAME_____

TITLE_____

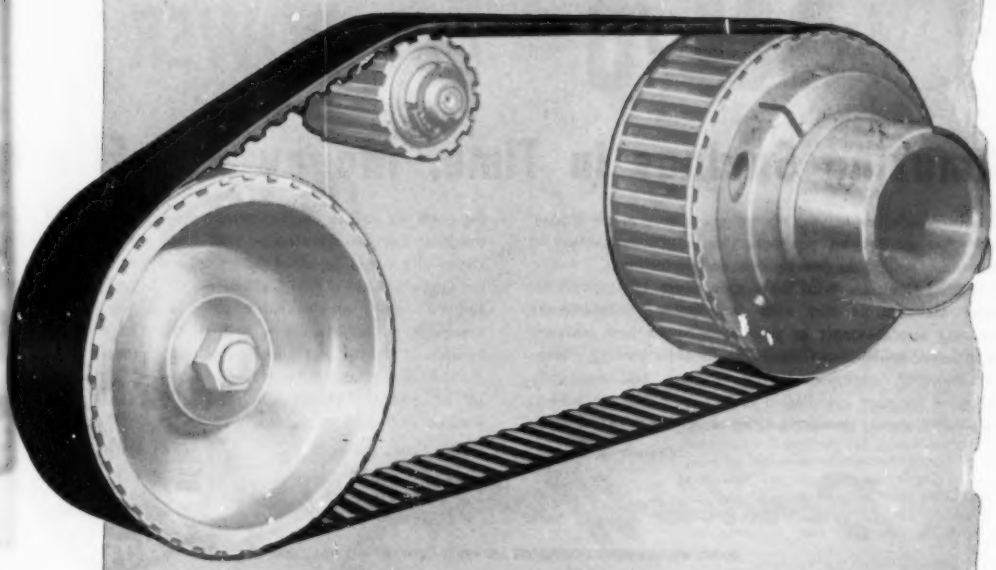
COMPANY_____

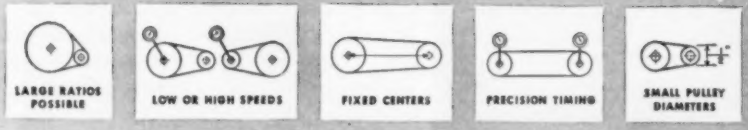
ADDRESS_____

CITY_____ STATE_____

All grip... NO SLIP!

GILMER





GILMER "TIMING BELT" PATENTED 1950

"TIMING BELT"* DRIVE

—designer's problem-solver

A revolutionary *tooth-grip* belt that has already improved the performance of thousands of machines—is daily solving new problems in power drive design!

The Gilmer "Timing Belt" is an exceptionally strong, *precision-power* belt: Belt teeth make positive engagement with axially grooved pulleys . . . speeds of driver and driven pulleys synchronize perfectly —there is no speed variation, angular velocity is constant.

And consider the construction! Steel cable pulling elements give enormous tensile strength—eliminate stretch. Where constant starts and stops are a factor, this extra strength reduces inertia by minimizing pulley weight. Body of belt is tough oil- and heat-resistant Neoprene for sturdy, long lasting service.

The Gilmer "Timing Belt" is *versatile:* You can use it for synchronizing drives, for power transmission, for functional operation! Let our engineers help design your drive. We'll be glad to send you an illustrated brochure which shows how leading design engineers are using it; gives valuable suggestions for drive designing. Write for it.

*Reg. Trade Mark

9 "TIMING BELT" "NO'S" Worth noting:

NO SLIP!
NO CREEP!
NO STRETCH!
NO SPEED VARIATION!
NO INITIAL TENSION!
NO POWER WASTE!
NO LUBRICATION!
NO ADJUSTING!
NO BACKLASH!

Gilmer BELTS

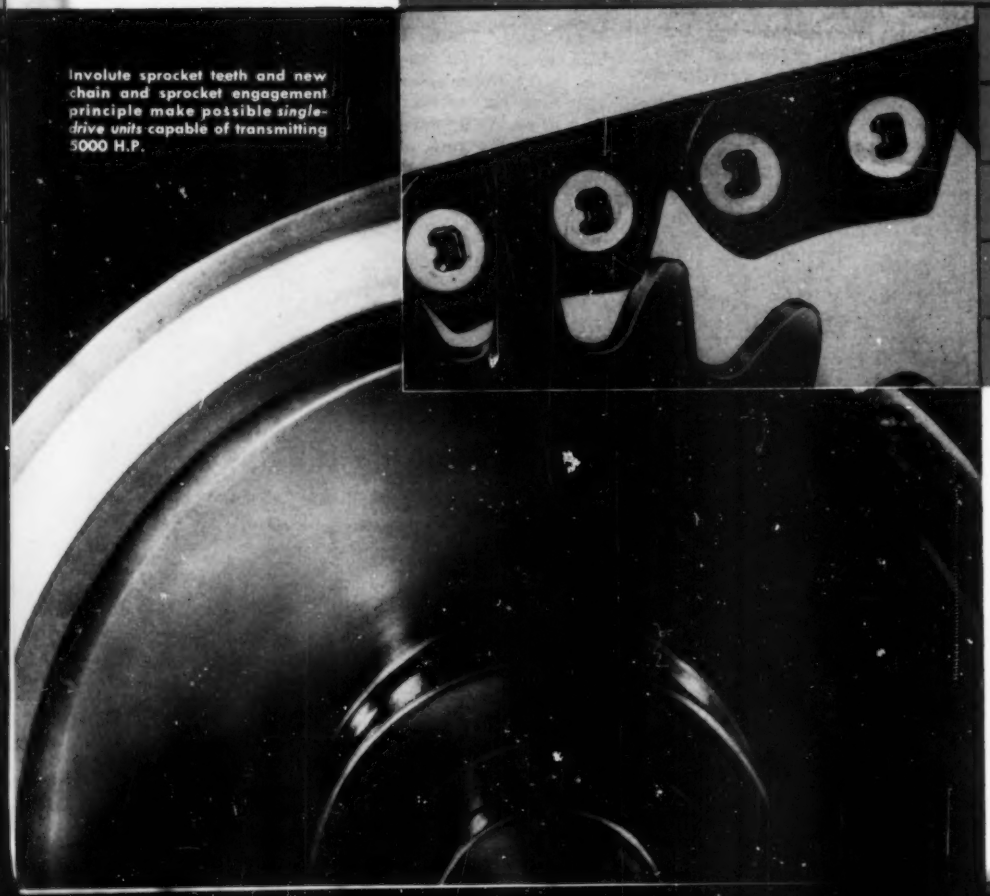
L. H. GILMER COMPANY
610 Tacony, Philadelphia 35, Pa.
Division of United States Rubber Company

Now—
more than ever

M=PT

Morse means
Power
Transmission

Sensational, new transmits more speeds than any



Involute sprocket teeth and new chain and sprocket engagement principle make possible *single-drive units* capable of transmitting 5000 H.P.

Morse HY-VO (TRADE — MARK) Drive

horsepower at higher other type of drive!

- More horsepower per inch of width
- Cuts cost-per-hour by as much as 50%
- Smooth and vibrationless as a belt
- Positive as a gear with the strength of steel
- Up to one-third longer service life

A 6" HY-VO Drive will transmit the same horsepower as a 24" belt drive.

The new Morse HY-VO Drive literally revolutionizes high-speed, heavy-duty power transmission. It combines—for the first time—the ruggedness and positive action of a gear with the smoothness and lack of vibration of a belt.

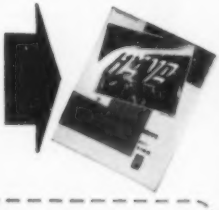
Entirely new design principles are used in the HY-VO Drive. Vibration and destructive linear pulsations are virtually eliminated, allowing the HY-VO Drive to operate at tremendously increased rotative speeds, using drives of much narrower widths. It opens the way for transmitting much higher horsepower from smaller, more economical, high-speed engines.

Due to the shortage of materials and production facilities, orders for HY-VO Drives must carry a priority rating at the present time.

MORSE CHAIN COMPANY

7601 Central Avenue, Dept. 179 • Detroit 8, Michigan

Write today for Catalog No. C-72-51



MORSE

MECHANICAL *POWER TRANSMISSION* PRODUCTS

PRODUCTS OF BW BORG-WARNER

DO NOT LUBRICATE
Simplifies installation in cramped quarters. The smaller size of Life-Line motors aided designers of machines and equipment . . . required less space. Pre-lubricated bearings eliminated extra fittings and piping.
FOR THE BEST DESIGN
USE Life-Line
Compact design minimizes required space. Life-Line starters installed in control cabinet on a precision lathe. Front removable parts and straight-through wiring saved additional space . . . facilitated general servicing.

Cramped?

Here's how to stretch space

Life-Line motors and Life-Linestarters® are space stretchers. The reason? "Compactness." They are smaller, lighter than most conventional types . . . often can be installed in close quarters where others cannot be accommodated.

Take the case of this grinder manufacturer, for example: The motor is mounted under the bed inside the housing. Space is at a premium. With ordinary conventional motors, it was necessary to grind part of the motor housing away so that motors could be squeezed into the available space. Life-Lines (as much as ⅓ smaller for the same frame size)—fit with room to spare.

Further, the pre-lubricated, sealed bearings eliminate the need for bringing grease fittings to the outside of the housing. This means an additional saving of several dollars per machine—in materials and labor.

Life-Linestarters match the motors for compactness. Because all parts can be removed straight from the front, there is no need to allow extra workroom for servicing. Further, straight-through wiring means simplified wiring, shorter leads, less space. You can have two electrical interlocks without increasing Life-Linestarter width. After that, two more may be added with little additional space.

These space savings result in smaller cavities . . . and more compact cabinets . . . reducing your costs. NEMA mountings are standard for the complete line.

More data? Complete information, on sizes and mounting dimensions, is available from your nearby Westinghouse representative. Ask him for copies of "Life-Line Motor Book", B-3842 and "Tomorrow's Starter Today", B-4677 or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21625

THIS ADVERTISEMENT is part of the current campaign aimed at the 14 million readers of The SATURDAY EVENING POST.

Is this clue to quality on your product?

BY USING PHILLIPS SCREWS on your product, you prove *on sight* that you use extra care in manufacture. The public knows that X marks the spot — the identifying X formed by the cross-recess on the head of every Phillips Screw. It is the mark of extra quality.

These screws — wood, machine or tapping — add structural strength, set up tighter, resist the loosening effect of vibration. They are speedier—and cost saving because they save time, work, money. They start faster, eliminate driver skids, damaged parts, split screw heads. They make good workers out of green help — fast!

Be sure to include Phillips Cross-Recessed-Head Screws in your specifications.

PHILLIPS *Cross-Recessed-Head* SCREWS

X marks the spot . . . the mark of extra quality

AMERICAN SCREW CO. • THE BLAKE & JOHNSON CO. • CAMCAR SCREW & MFG. CORP.
CENTRAL SCREW CO. • CONTINENTAL SCREW CO. • ELCO TOOL & SCREW CORP.
GREAT LAKES SCREW CORP. • THE H. M. HARPER CO. • NATIONAL LOCK CO. • PARKER-KALON CORP.
PHEOLL MANUFACTURING CO. • ROCKFORD SCREW PRODUCTS CO. • SCOVILL MANUFACTURING CO.
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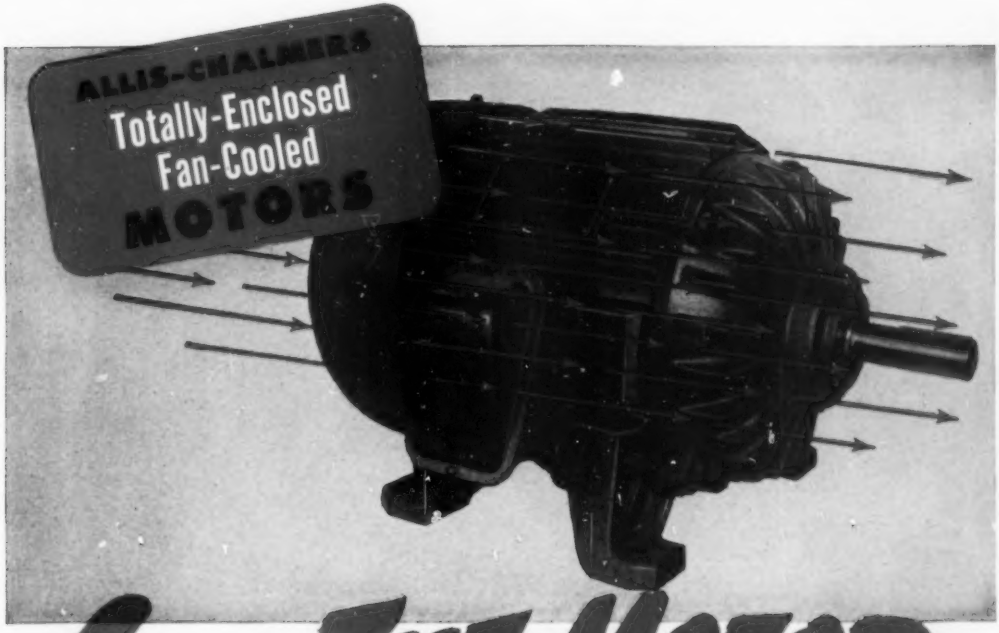
THE FASTENERS OF TODAY . . . AND OF THE FUTURE



USE THE MOTOR that Cleans Itself

YOU CAN CUT DOWN on motor cleaning operations and greatly reduce inspections and overhauls on the equipment you design. Tests have proved that on most applications totally-enclosed, fan-cooled motors more than pay back their extra cost in reduced maintenance. And this new Allis-Chalmers Type APZ tefc motor makes maintenance costs lower than ever before on this type of motor.

Here's Why

Concealed air passages and pockets have been eliminated; dirt cannot build up to cause overheating. Cooling air is blown over the ribbed cast iron frame and bearing housings carrying dirt away with it. How about oily dirt that sticks? It can be wiped or blown off without stopping the motor.

Rigid Construction

The frame is rigid cast iron which not only has high inherent corrosion resistance, but also holds bearings permanently in alignment. Bearings are prelubricated at the factory and should need no attention for years. Tapped holes with pipe plugs to permit regreasing and to provide grease relief are standard equipment.

Get All The Facts

The new Allis-Chalmers Type APZ totally-enclosed, fan-cooled motor is built in all NEMA standard frame sizes from *224 to 505. Also in explosion-proof type. Your A-C Authorized Dealer or District Office offers you competent engineering aid on your design problems. Call today, or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B6144.

A-3402

Sold . . .
Applied . . .
Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

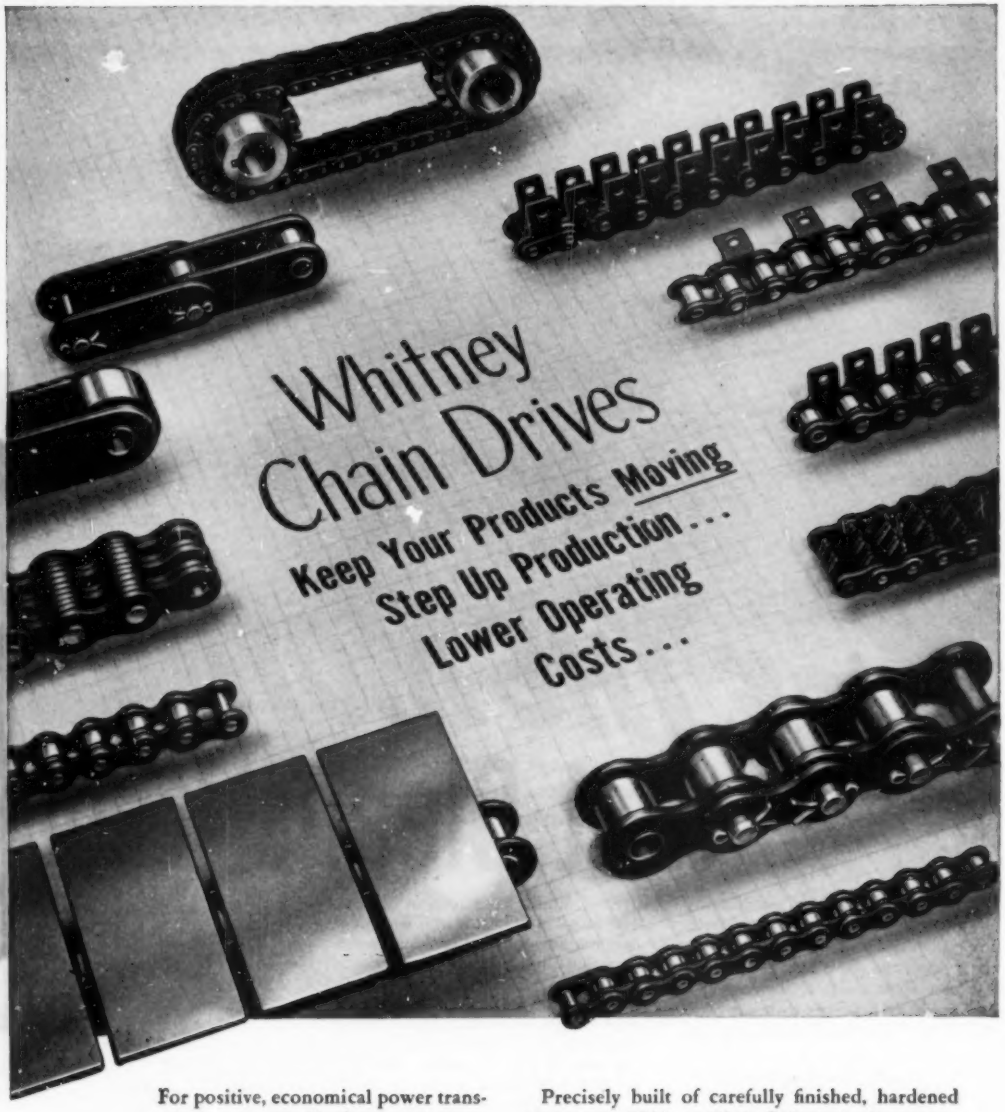
TEXROPE — Belts in all sizes and sections, standard and Vari-Pitch sheaves, speed changers.

PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

Texrope and Vari-Pitch are Allis-Chalmers tredemarks.

ALLIS-CHALMERS

*Similar design non-ventilated motors Type APK, also available in frames 203 to 224 inclusive.



For positive, economical power transmissi . . . smooth flowing conveying of bottles or packaged goods at high or low speeds . . . transferring bulk materials . . . split second timing motions where accuracy has top priority.

If these are your problems, Whitney Chain Drives will provide the solution with savings in time and money.

And not only do these adaptable chain drives fit perfectly into your design planning. What's more, they insure top machine performance by maintaining a constant, high level of uniform production.

Precisely built of carefully finished, hardened alloy steels, Whitney Chain Drives give long service life . . . keep maintenance at a minimum, assure maximum output and lower costs.

WHITNEY SERVICE

In addition to the service facilities of over 130 Distributors, Whitney maintains a network of 15 Field Engineering Offices located throughout the country. From the complete line of Roller, Silent and Conveyor Chains, Whitney Engineers can recommend, without bias, the proper type of drive for your application. Consult your nearest Whitney Field Office or write us direct for catalog and complete information.

WHITNEY CHAIN COMPANY

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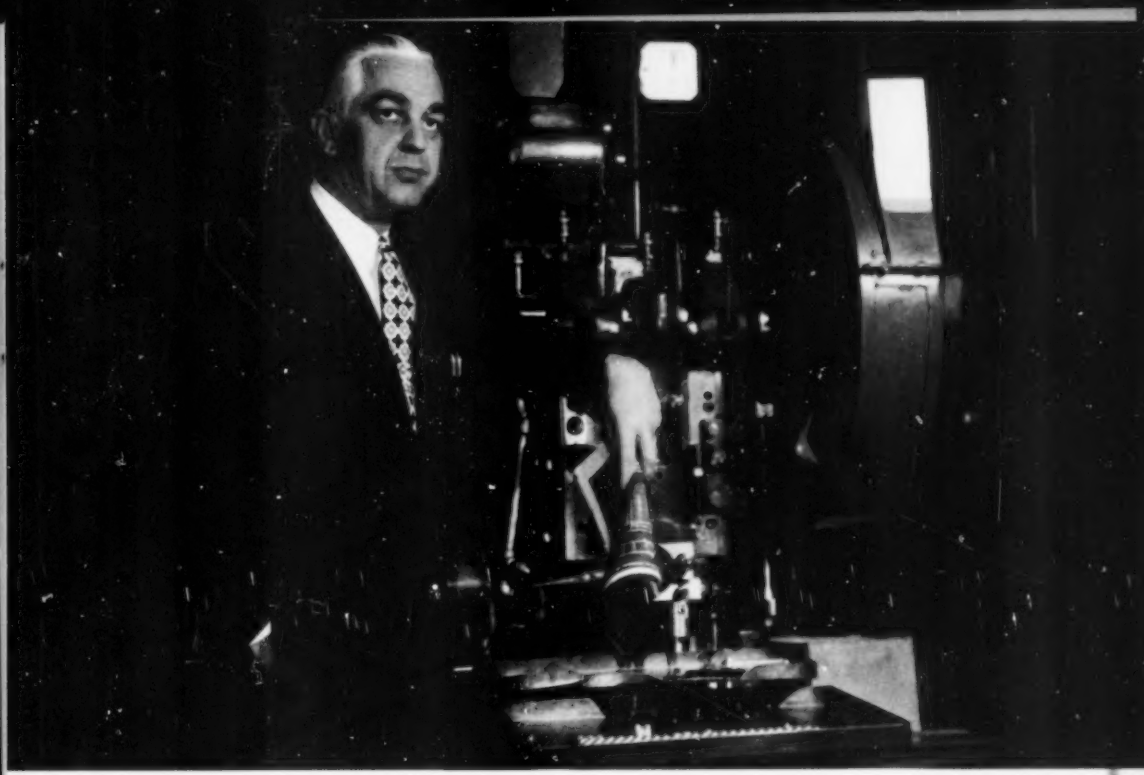
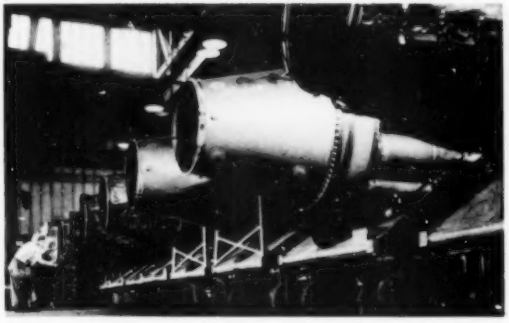


FRED A. HOFMANN, production vice president of the Elastic Stop Nut Corporation of America, says, "We're back on a full 2-shift production schedule, and practically every one of the 62 Tri-Clad motors we've installed since 1941 in our plant at Union, N. J., is going night and day. Sure, we make a lot of steel products, but for a general-purpose motor, we don't think you can beat cast iron. After the pounding we've given our Tri-Clad motors for the past 10 years, we're stronger than ever for Tri-Clads."

ELASTIC STOP NUT CORPORATION:

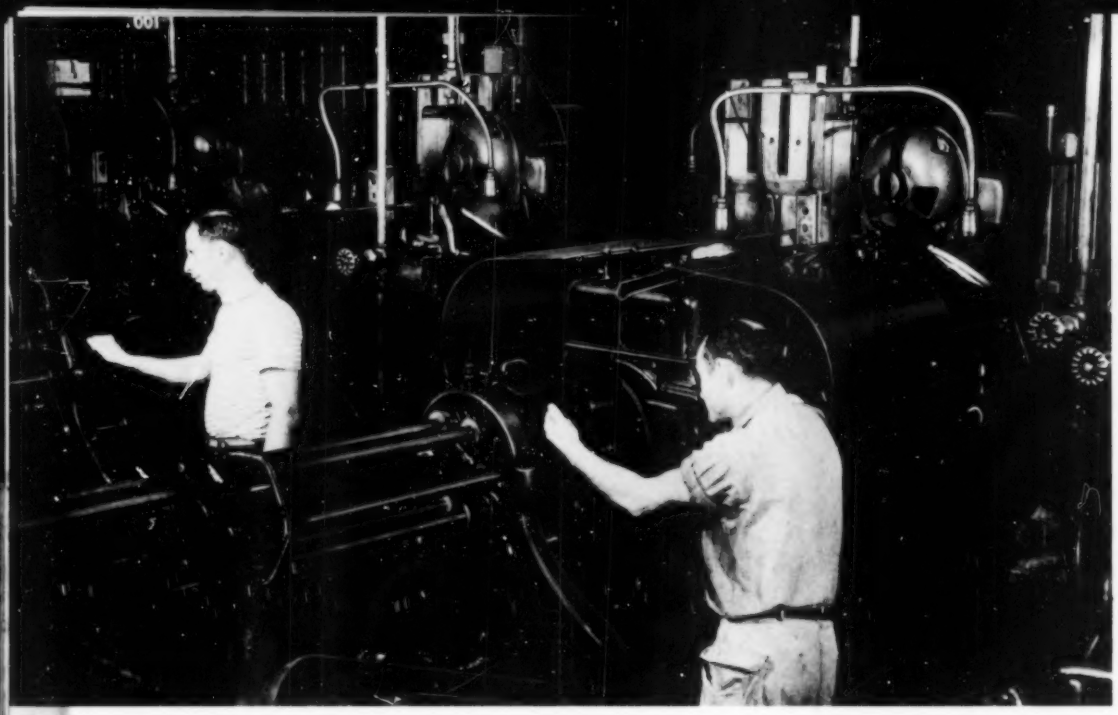
"We're stronger than ever for Tri-Clad triple protection!"



TRI-CLAD MOTORS drive machines that produce ESNA fasteners for use on jet aircraft engines—the engines that power our modern military planes. Each of the jet engines above uses a large number of these special stainless-steel high-temperature nuts, designed to hold under the extreme heat and other severe conditions of jet-engine operation. Moreover, these nuts must be re-usable without seizing or galling the finish. ESNA counts on the reliability of their Tri-Clads to help turn out thousands of these fasteners every day.

VIRILE VETERAN. This 10-hp Tri-Clad motor has been driving an Acme Gridley multiple spindle bar machine for nearly 10 years. It's still going strong, another reason why, after 10 years, ESNA thinks Tri-Clad is still their best motor buy! And today's Tri-Clad motor, all-industry favorite, is better than ever!

GENERAL ELECTRIC



4 STEPS—AND NO HANDS! Backbone of the ESNA production line, the Acme Gridley automatic bar machine (3 shown above) ejects a finished nut blank every 4½ seconds. The operator simply keeps the six spindles supplied with bar stock. The machine feeds stock, machines the nut profile, drills 2 holes and cuts off to accurate lengths. The load on the 10-hp drive motor is heavy and constant—but Tri-Clad, with its bearings completely enclosed in cast-iron housings, can take it! Maintenance department can't recall a single Tri-Clad bearing ever having to be replaced. Moreover, if they need it, the motors are easily greased while running.

GE

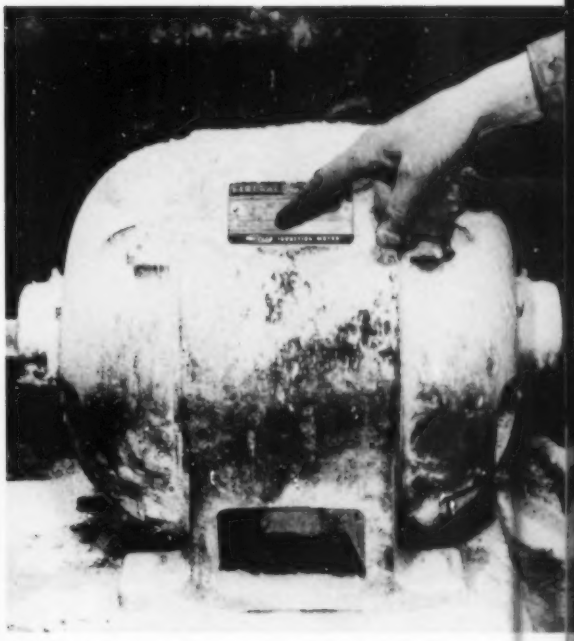
TRI CLAD MOTORS

REG U.S. PAT. OFF.

Help Keep ESNA Production Up!

PRODUCTION PUSHER General plant foreman Karl Kjellburg has the job of meeting "impossible" defense program manufacturing schedules. He's counting heavily on automatically fed machines like the Tri-Clad driven V. & O. press on his left; says, "This press inserts over 200 elastic fibre locking collars a minute in a $\frac{3}{8}$" fastener. Driving it is a big job for a motor. Our Tri-Clads gave us no trouble during the war. We're counting on them again!"

TROUBLE SHOOTER TESTIFIES Ed Conk, ESNA's maintenance chief, must furnish reliable power wherever it's needed in the plant. He's got some definite ideas about electric motors; says, "We like a motor you can regrease easily *if you have to.* So far, we've had to regrease very few of our Tri-Clad motors. And those were either on hot spots or on particularly tough jobs. The point is—we *could* readily have regreased them all if it was necessary."



TOUGHEST... on the inside Extra protection against electrical breakdown is built into every Tri-Clad motor. Formex* wire windings, one-piece cast-aluminum rotor, double-end ventilation—these are features that prolong a general purpose motor's useful life.

TOUGHEST... on the outside Teeth rattling blows, dripping liquids, corrosive fumes—they're all in a day's work for Tri-Clad cast-iron construction. You get a rigid structure, too—one that won't twist out of line when you're bolting it down.

TOUGHEST... at the bearings A Tri-Clad motor will run safely without relubrication for as long as any general purpose motor you can buy. But, if the application does make relubrication a "must", you can grease your Tri-Clad without halting production.

** Reg. U.S. Pat. Off.*

How to Keep Your Motors in Shape for the Job Ahead!

TIMELY READING With every electric motor needed on the line, once again it's time to be a crank about motor care. That's why every motor user needs this General Electric manual. Tells how to spot motor and generator trouble before it happens, how to prevent serious breakdown, how to conduct a regular motor maintenance program. Order a copy for your maintenance department today! Use the coupon!

General Electric Company
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Schenectady 5, New York

Please send me my free copy of "How To Maintain Motors and Generators" (GET-1202)

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GENERAL ELECTRIC

Turn the page for the latest news on motor selection and application. ➡

NEED HELP IN TRAINING MANPOWER?

Here's a Valuable Tool! —G-E's New Course on

MOTOR SELECTION AND APPLICATION

9 Slide Films and Accompanying Manuals To Help You Get the Most Out of Electric Motors

Timed to help meet the growing demand for skilled industrial workers, this new General Electric Motor Selection and Application Course is a boon to everyone concerned with technical training problems. Here, in 9 short, easily understood lessons is a "how-to" course that offers a broad introduction and review of motor principles and uses to engineers, plant personnel, students and all others concerned with motors. *It's a valuable production-boosting tool for any type plant!* Ask your G-E representative for more details on this course or mail the coupon today.

HERE'S WHAT THIS COURSE CONSISTS OF:

9 Sound slide films and records. 9 Sets of Review Booklets (10 per set) for student use. 1 Instructor's Manual—(This 96-page manual is virtually a complete course in itself.) Complete kit—Slide films, Review Booklets, and Instructor's Manual, in sturdy carrying case—**$100.00.**

Here's a Quick Look at the Scope of the Course

Lesson 1—"Fundamentals of Motors"—Basic principles of motor operation, how a-c and d-c motors work, construction features, etc.

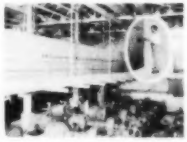
Lesson 2—"Types of Motors"—Horsepower, speed and torque and other characteristics, ranges of application, design features.

Lesson 3—"Fundamentals of Selection"—A study of the five basic steps that are usually followed in the selecting of any motor.

Lesson 4—"A-C Polyphase Induction Motors"—Characteristics of the three basic types: squirrel-cage, wound-rotor, adjustable-speed induction.

Lesson 5—"Single-Phase Integral-HP Motors"—General range of applications, torque and safety factor, capacitor and repulsion-induction types.

Lesson 6—"D-C Motors"—Basic types: shunt, series, compound; horsepower formulas, adjustable speed applications, versatility, etc.



Lesson 7—"Synchronous Motors"—Where used, design features, power factor improvement, and other basic operating benefits.

Lesson 8—"Adjustable-speed Drives"—Speed range and versatility of various packaged adjustable-speed drives, typical applications.

Lesson 9—"Gear Motors"—Selection and application of the three classes of gear units. Advantages of these low-speed drives.

MAIL THE COUPON TODAY!

(Attach this coupon to your business letterhead and mail Today)

General Electric Company
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Gentlemen:

Your Motor Selection and Application Course sounds like it may be valuable in our training program.

☐ Send me a complimentary copy of the Course Manual, GEZ-310, for my inspection, at no cost to me.

☐ Send us a complete course for a 10-day free trial. If we do not return the course at the end of the trial period, you are to bill us $100.00 for this complete course.

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GENERAL ELECTRIC

684-20

Simplify Your Access Panel and Door Assemblies...

Fastening removable access doors and panels need not be a laborious and costly production or assembly operation—not if they're fastened with QUICK-LOCK.

Designed for simple installation, QUICK-LOCK requires no special tools. It speeds up mounting and demounting detachable panels with only a 90° turn required to lock and unlock it *in a jiffy*.

The flexible mounting and tapered stud makes QUICK-LOCK ideal for assembling curved sheets and insures a tight fit when locked. Stud is self-ejecting when unlocked. Minimum deflection is assured—only initial loads are carried by the helical spring. Solid supports take up increased loads.

Industrial and agricultural equipment manufacturers would do well to analyze the cost-saving features of QUICK-LOCK's simple design. A good way would be to call in a Simmons Engineer and discuss the economy of a QUICK-LOCK installation as compared to your present fastening method. Why not send for him today?

SIMMONS FASTENERS

SIMMONS FASTENER CORPORATION • 1751 NORTH BROADWAY, ALBANY 1, N. Y.

BELVEDERE BOWL— with Griptite* base developed by Goodyear. Design meets precision requirements for dimensions, hardness, resistance to fats and oils. Note metal valve insert bonded to rubber base.

Business as Unusual

THANKS TO GOODYEAR PRECISION-MOLDED RUBBER

AN unusual product that may show YOU the way to a new or better design is the Belvedere Mixing Bowl, with its Griptite base that lets a woman use both hands for kitchen mixing.

Problem here was to mold a rubber base that would hold a mixing bowl to the kitchen counter. It required an airtight seal that would hold even under the stress of stirring, yet be instantly releasable. The answer was *precision molding*—the kind of work that characterizes all the output of Goodyear's Molded Goods Plant at St. Marys, Ohio.

Whether you need simple parts or complex shapes—molded or extruded, compounded to meet specific requirements—you can be sure of exact, uniform quality and performance, thanks to advanced production techniques, rigid inspections and controls at this plant—world's largest devoted to producing molded and extruded items from rubber and the new rubber-like plastics.

If you have a design or production problem rubber may solve, turn to the G.T.M.—Goodyear Technical Man—or write direct to Goodyear, Molded Goods Dept., St. Marys, Ohio.

MIX—WITHOUT HOLDING —rubber base enables bowl to adhere to any smooth surface — lets women mix without holding bowl, frees other hand for pouring.

We think you'll like
"THE GREATEST STORY EVER TOLD"
Every Sunday—ABC Network

*Griptite—T.M. Griptite Corporation, Lancaster, Ohio

GOODYEAR

THE GREATEST NAME IN RUBBER

Here's how you can tell the chain with SHOT-PEENED rollers...

Thousands of tiny steel balls hammer the metal — "cold work" each roller . . . pay off in extra fatigue life . . . added ability to withstand shock and impact.

...the chain that has extra fatigue life

YES, you want to be sure you get shot-peened rollers on the next roller chain you buy. Shot-peening gives rollers the extra fatigue life needed to take repeated shock and impact loads.

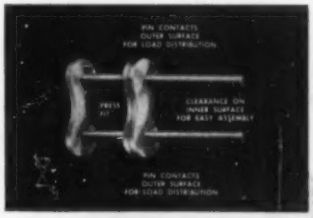
These chains are high in tensile strength, durable under severe loads, relatively light in weight and uniform in pitch. This accounts for their wide acceptance throughout industry for both drive and conveying purposes.

Thanks to constant research and precise manufacturing controls, every Link-Belt Precision Steel Roller Chain meets the highest standards for uniform strength. You get a positive, long-life drive — unaffected by heat, cold or moisture.

Link-Belt Roller Chain is available in single or multiple widths, in 3/8 to 3 in. single and double pitch. For all the facts, call your nearest Link-Belt office.

LINK-BELT

PRECISION STEEL ROLLER CHAIN



Easier coupling
and uncoupling without sacrificing load distribution

Patented E-Z Assembly feature of Link-Belt Precision Steel Roller Chain has won world-wide approval. Coupling and uncoupling of multiple width chains — right on the job — is far easier. There's absolutely no sacrifice of load distribution . . . no loss of the chain's remarkable performance. Press-fits between chain pins and middle bars have been modified. But full load carrying capacity across the entire width of the chain has been maintained.

LINK-BELT COMPANY: Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in principal cities. 12,332

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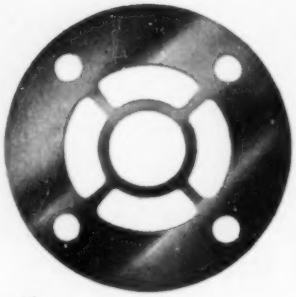
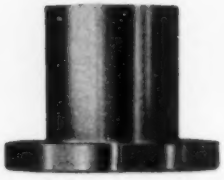
(CARBON-GRAPHITE)

saves critical material · saves weight



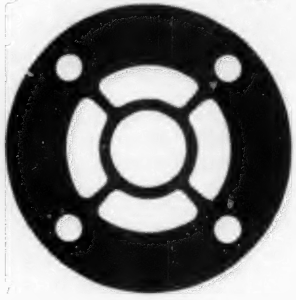
Gasoline meter valve-seat formerly made of bronze.



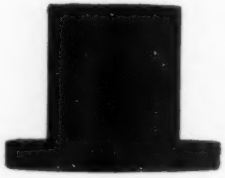
Former copper — tin — lead industrial bushing.

Piston, previously cast and machined from aluminum.

New valve-seat, now made of weight-saving Graphitar.



New bushing identical in size, shape and with better performance now made of Graphitar.



New Graphitar piston of equal lightness which is giving improved performance.

THE UNITED STATES

improves performance

The six examples on these pages are typical instances in which GRAPHITAR is saving STEEL, BRONZE, ALUMINUM and nearly every other metal and alloy usually employed for small machinery parts such as bearings, seals and bushings.

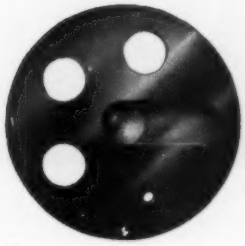
And here's the payoff! — GRAPHITAR is not only saving critical metal and weight — it is improving the performance of nearly every product in which it is used!

GRAPHITAR is strong, self lubricating and resistant to wear and extreme temperatures. It resists chemical attack — even by concentrated acids such as hydrofluoric and hydrochloric.

Let us show you how GRAPHITAR can save critical metal and improve the efficiency of your products. Write us today for the full story and our descriptive 64 page catalog.

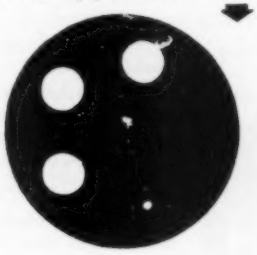
Former nitrided steel aviation gasoline pump liner.

New Graphitar liner lubricates itself — is unaffected by wear or gasoline.



Former steam valve rotor, machined from stainless steel.

New rotor made of Graphitar provides perfect seal, is unaffected by pressure or steam.



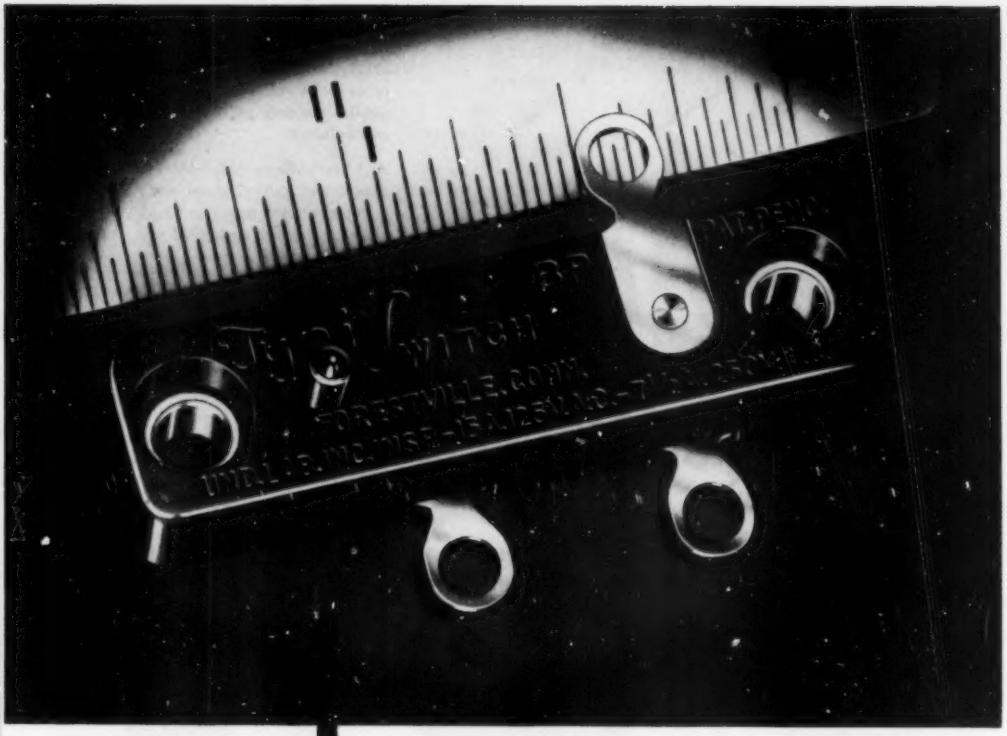
Bronze current collector wheel for overhead crane trolley.

Improved, durable wheel finish ground from Graphitar.

155

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN



Illustrated: Model BP Single-pole, double throw 15 A., 125 V. A-C

The only miniature snap switch

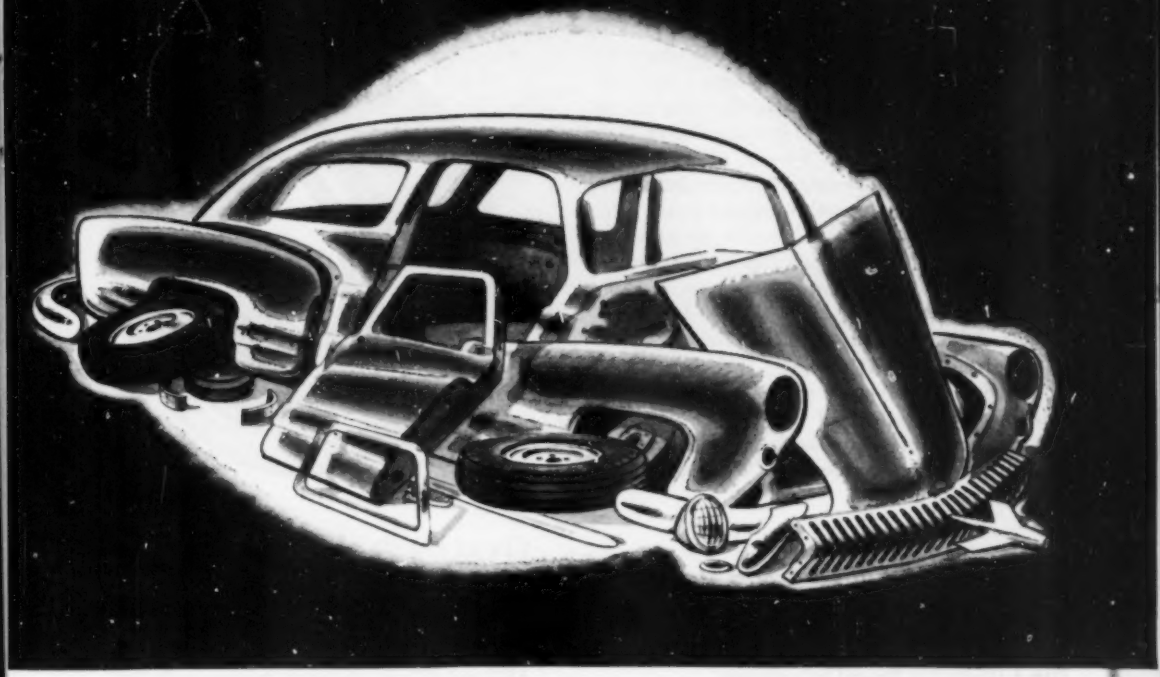
. . . where size and high rating come to terms with cost

Here's a new ally for the design engineer in his effort to keep quality high and cost low. TYNISWITCH fits in the smallest places, yet handles the load of switches much larger and more expensive. Thorough laboratory tests have proven its dependability and durability at high operating speeds and over millions of cycles.

In its simplified construction, TYNISWITCH introduces new principles of switch design that cut costs. High force-to-inertia-ratio spring blade inhibits mechanical resonance, enables high switching rate with positive bounceless closure. All these and other features add up to efficient switching at low cost.

TYNISWITCH engineers are fully qualified to work with you on the economical development of your special application switches. Write for engineering design sheets.

Ever See a Car **Without Fasteners?**



APPROXIMATELY 2½% OF THE STEEL PRODUCED IS USED TO FASTEN THE REST TOGETHER!

Like so many important little things in our every day life, people are apt to take glamorless bolts and nuts for granted. But it takes only a second to realize what a tremendous contribution they make to our way of living.

The importance of fasteners is fully realized by the designers, the engineers, production men and top executives of industry. And they know, too, that Lamson & Sessions is their most reliable source of supply—with one of the most complete fastener lines of any manufacturer.

Look to Lamson for progress in fasteners. We welcome your inquiry on *any* fastener problem.

The home of "quality controlled" fasteners

Lamson + Sessions

The **LAMSON & SESSIONS** *Co.* • • **General Offices: 1982 West 85th Street • Cleveland 2, Ohio**

Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

Standard bearings can cut your costs...

When you want anti-friction performance in your product, consider the possibilities of "Commercial" ball bearings. Schatz "Commercial" ball bearings can economically replace bushings or plain sleeve bearings, and thus improve product performance without adding a price premium. "Commercial" bearings can often substitute for costly precision bearings too, when tolerances aren't tight.

So be sure to investigate the standard line of Schatz "Commercial" ball bearings. This line includes 22 basic types, both ground and unground; some types are available in metric sizes.

The careful manufacture of Schatz "Commercial" ball bearings insures top performance.

"Commercial" bearings are now in heavy demand because of their versatility and wide design possibilities. But Schatz engineers will welcome the chance to help you conquer friction economically. Write for catalog No. 11 today.

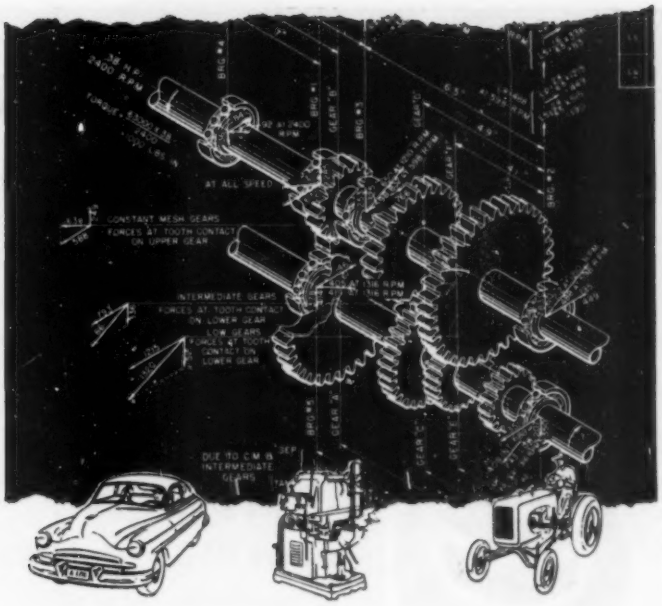
Check these Schatz standard types before you specify bearings:

Type A (unground) double row ball bearings
Type A (unground) thrust ball bearings
Type A (unground) flanged ball bearings
Type A (unground) plain dust-proof ball bearings
Type A (unground) flanged set screw ball bearings
Type A (unground) flanged ball bearings with set screws and UU seal; and with Alemite fitting
Plain Type A (unground) set screw ball bearings
Double Row Type A (unground) set screw ball bearings
Type A (unground) ball bearings with set screws and UU seal; and with provision for relubrication
Type B (ground) set screw and plain dust-proof ball bearings; and plain dust-proof ball bearings
Type A (unground) radial-thrust ball bearings
Type B (ground) banded thrust ball bearings
Type ADX (unground) ball bearings
Type A (unground) ball bearings with UU seal
Type AHR (unground) heavy duty ball bearing rollers
Type AA (precise) single row ball bearings; and Type ARX and ARXX (unground) ball bearing rollers
Ball bearings with metric dimensions
Type A (unground) flanged ball bearings with hex bores
Type KR, KRS and KRP ball bearing rollers with hardened tread
Type KRSF ball bearing rollers with hardened tread; and Type KR and KRS double row ball bearings with hardened tread
Unground radial-thrust ball bearings; and Type A (unground) ball bearings with long inner race
Type BHR (ground) extra heavy duty ball bearing rollers

THE SCHATZ MANUFACTURING COMPANY
6758 Fairview Avenue · Poughkeepsie, New York

SCHATZ "Commercial" BALL BEARINGS

If You Have a Friction Problem Let Schatz Engineers Design it Away



Beating Friction... with Advanced Engineering

Quality bearings play a vital part in engineering progress. Their contribution to automotive engineering advances is a good example: by reducing friction and wear at critical points, precision-made bearings have helped automakers produce high-performance cars on a mass basis.

In seeking peak performance, automotive engineers have consistently relied on Federal as a supplier of precision-made bearings for thirty-five years. That's because Federal has more than kept pace with engineering progress in anti-friction bearing design.

Federal is "first-choice" as original equipment in machine tools, agricultural machinery, textile equipment, as well as in cars and trucks, because Federal's reputation for quality bearings is based on top flight engineering, manufacturing, and research skills. Design engineers, when they specify Federal ball bearings in quality products, can expect top performance and high efficiency.

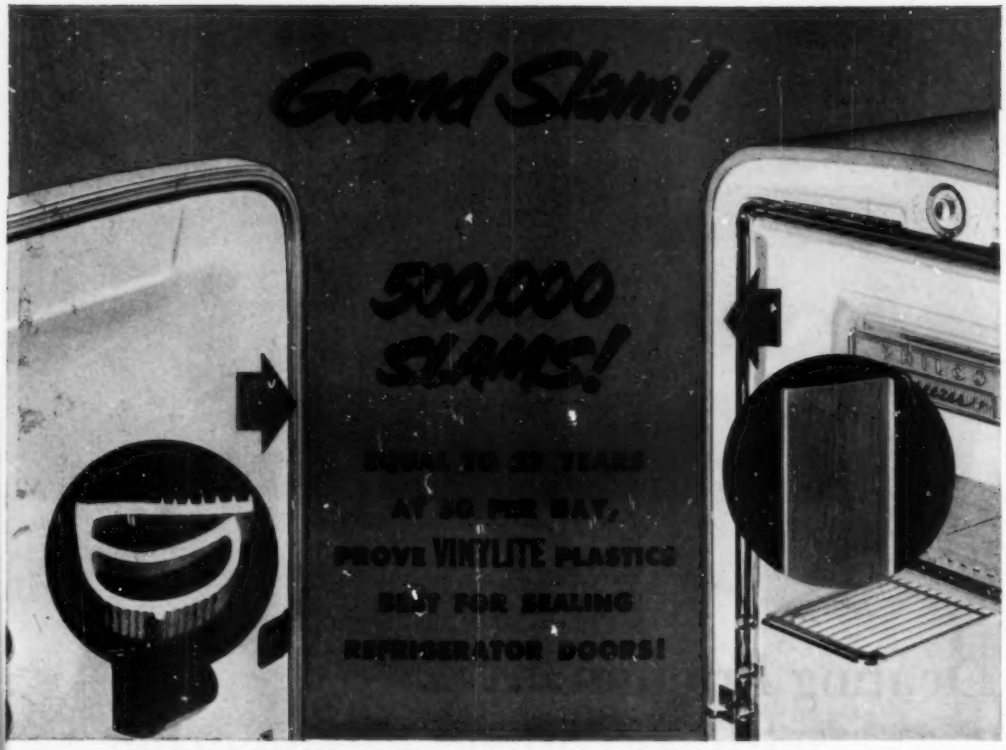
When friction is a problem, and tolerances are tight, be sure to turn to Federal ball bearings—products of the combined skills of IMAGINATIVE RESEARCH · ADVANCED ENGINEERING · ALERT MANUFACTURING · RIGID QUALITY CONTROL · SUPER-PRECISE TESTING.

THE FEDERAL BEARINGS CO., INC.
POUGHKEEPSIE, NEW YORK
Makers of Fine Ball Bearings

Federal BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

Quality Since 1908



YES, Westinghouse slammed the door of one of its new home refrigerators a half million times—to prove the durability of their beautiful new flexible door gaskets extruded from VINYLITE Elastomeric Plastics. Philco also ran grueling tests on its new models to show that VINYLITE Rigid Plastic breaker strips (facings against which the big doors shut) could absorb similar punishment!

Additional tests demonstrated the resistance of these materials to food acids and alkalies, greases and oils, moisture, cleaning, abrasion and resistance to cracking from age.

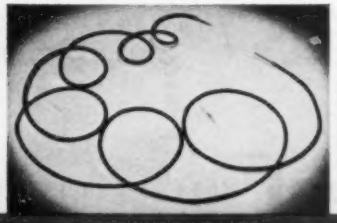
Conclusion: Versatile VINYLITE Plastics are in domestic refrigerators to stay, for gaskets, breaker strips, shelf supports, seals, grommets, bumpers, other parts.

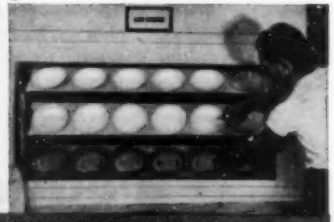
We think we can show how they can upgrade your products, too—particularly if they require materials with a specific degree of flexibility or rigidity, plus ease of fabrication, plus a rainbow range of colors, at a reasonable cost. Tell us your specific problem. Write Dept. KO-10

Vinylite BRAND **PLASTICS**

TRADE MARK

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.





Save Cost...Save Servicing...Aid Selling!

CHECK THESE THREE big advantages of using *Magic-Grip* sheaves on your machines:

1. They're faster, easier to put on than any other sheave made. *Magic-Grip* sheaves save labor cost to original equipment manufacturer. And users save every time they mount or demount the *Magic-Grip* sheave.

2. Eliminate damage to bearings and shafts encountered when hammering or prying ordinary sheaves on or off. *Magic-Grip* sheaves go on and off fast and easy.

3. Biggest name in sheaves is *Magic-Grip!* Your customer is assured of quality when *Magic-Grip* sheaves are used on your machine.

Best of all, *Magic-Grip* sheaves cost no more than ordinary sheaves. Sizes 1 to 250 horsepower.

ONE SOURCE FOR EVERYTHING

The *Texrope* line offers the most complete selection of V-belts, speed changers, and standard and variable speed sheaves in the industry. In addition, you get the extra engineering skill that results from having more industrial V-belt installations than any other manufacturer.

GET FACTS AND FIGURES

Big 120 page *Texrope* Pre-Engineered Drive Manual 6956A lists sizes and dimensions of drives to fit more than 90% of all fixed speed applications. Handy Guide (6051) gives condensed V-belt and sheave information. Ask your Allis-Chalmers Authorized Dealer or Sales Office for either of these booklets, or write Allis-Chalmers, Milwaukee 1, Wisconsin.

Texrope and *Magic-Grip* are Allis-Chalmers trademarks.

Sold . . . A-3244

Applied . . .

Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

MOTORS — ½ to 25,000 hp and up. All types.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

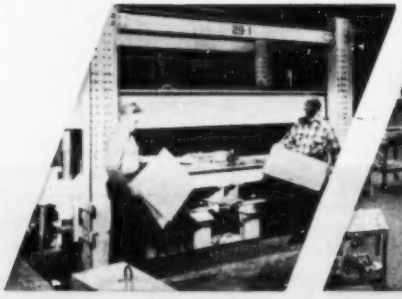
PUMPS — Integral motor and coupled types from ¾ in. to 72 in. discharge and up.

ALLIS-CHALMERS

See General American for plastics facilities unmatched...anywhere!

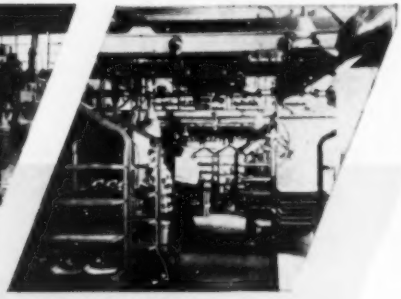
Make General American your complete molding source for *defense* and *civilian* production. Use most modern production-line equipment available . . . *facilities unmatched* anywhere in scope and versatility. Take advantage of skilled personnel . . . engineers, die-makers, set-up men. Ask to see samples of General American's experience with hundreds of different plastics applications . . . which have speeded production and bettered products in many industries. Write us about *your* problem . . . we'd like to help you.

PLASTICS DIVISION GENERAL AMERICAN TRADE MARK



LOW PRESSURE MOLDING
48" x 144" low pressure molding of reinforced plastics . . . supplemented by smaller presses.

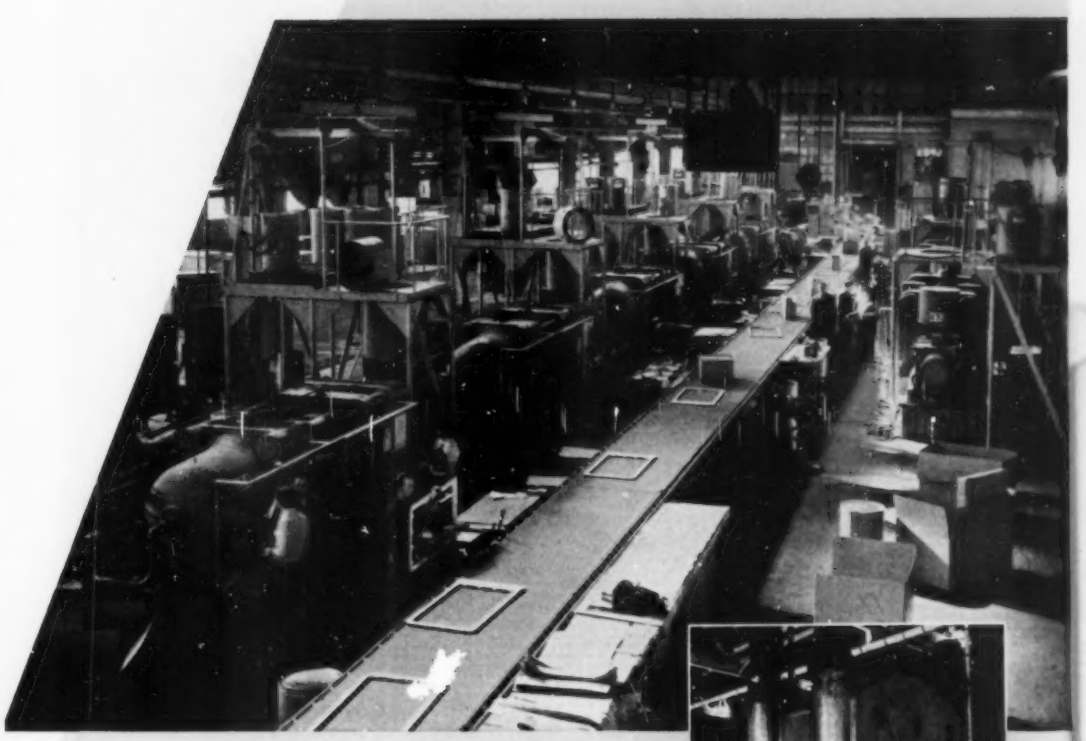
TOOL AND DIE SHOP
General American maintains one of the most extensively equipped and modern shops in the country. Completely mechanized.



IN ADDITION . . .
General American offers high speed Logoquant-treating and painting . . . plus a complete assembly and packing service.

MORE MEN AND MACHINES TO PRODUCE YOUR PRODUCTS BETTER

PLASTICS DIVISION • GENERAL AMERICAN TRANSPORTATION CORPORATION

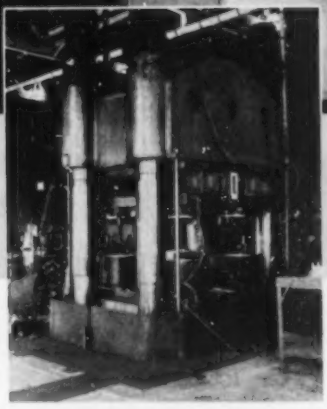


HIGH-SPEED INJECTION MOLDING

Injection equipment at General American includes largest machines ever built.

An overhead crane supplies material. Continuous conveyors carry away finished products.

1—2 oz. machine
3—8-oz. machines
2—16 oz. machines
10—22 oz. machines
4—32 oz. machines
(either Acetate or Polystyrene)
4—48 oz. machines
(either Acetate or Polystyrene)
5—48 oz. for Polystyrene
or 60 oz. for Acetate
2—85 oz. machines
(either Acetate or Polystyrene)
1—300 oz. machine
(either Acetate or Polystyrene)



MULTI-CAVITY COMPRESSION MOLDING
up to 71" x 74" platen areas

General American compression presses have turned out some of the largest plastics pieces ever produced.

3—2000 ton presses
1—1400 ton press
1—1200 ton press
2—1000 ton presses
4— 500 ton presses
10— 350 ton presses
6—100 ton presses

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 S. La Salle Street • Chicago 90, Illinois • New York 17, 10 E. 49th Street • Detroit 2, 2842 W. Grand Blvd.

clothes dryers to deep fryers

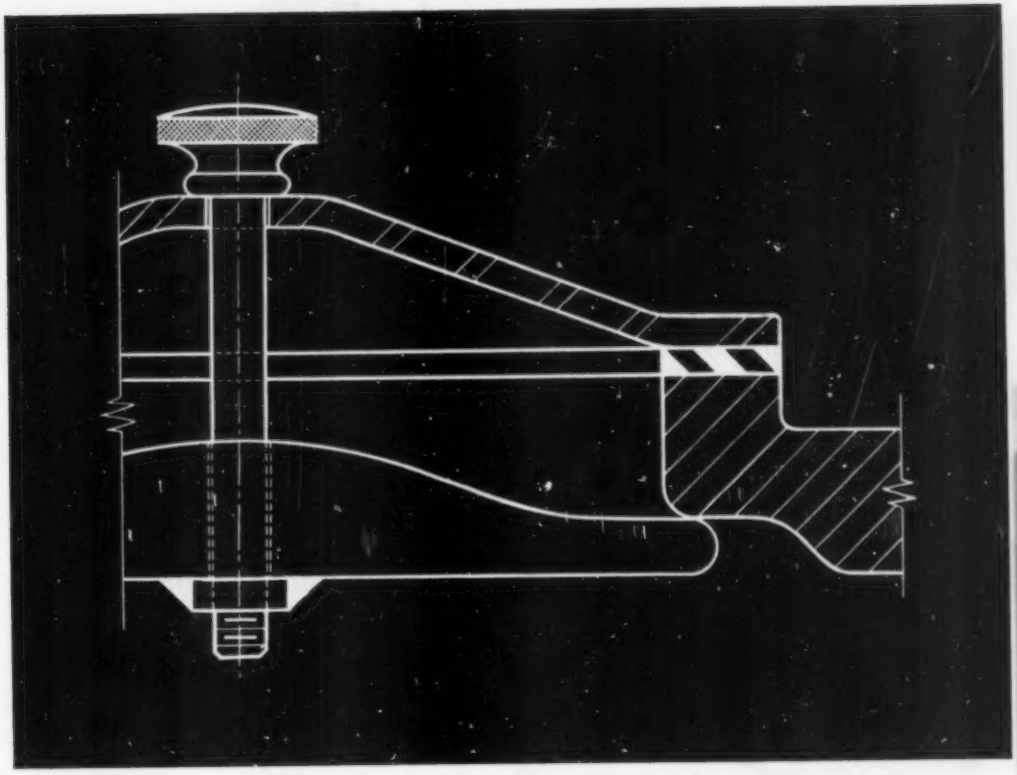
Clothes Dryers
Automatic Washers
Dishwashers
Refrigerators
Home Freezers
Vacuum Cleaners
Electric Ventilators
Dehumidifiers
Fruit Juicers
Electric Deep Fryers

wire cloth
FOR HOME APPLIANCES

Whether the wire cloth is to be "standard" . . . or "strictly to specifications" . . . or through "start from scratch" new development problem—Reynolds engineers are right at home in the home appliance field. And in other fields—automobiles to aircraft . . . farm harvesters to fly swatters . . . floor furnaces to faucet filters. And for the same reasons—Reynolds' fifty years of fabricating wire, and many, many more years of research measured in engineering man-hours. If you use wire cloth, Reynolds engineers can be helpful. Consult them without cost or obligation.

REYNOLDS WIRE DIVISION
NATIONAL-STANDARD COMPANY
DIXON, ILLINOIS

NS NATIONAL-STANDARD Company



Military applications for cork-and-rubber gaskets

Here are answers to a few of the questions design engineers are asking us about military applications of cork-and-rubber gasket compositions.

Where is cork-and-rubber most useful in military applications?

Cork-and-rubber is used effectively to seal: (1) metal-to-metal joints, (2) stamped and rough cast parts, (3) joints which will be repeatedly opened and resealed in the field, and (4) in any application where it is desirable or necessary to combine the compressible and frictional qualities of cork with the solvent and weather resistant qualities of synthetic rubber.

Can cork-and-rubber be used in equipment intended for low-temperature operations?

Yes. Most standard compounds may be used at temperatures as low as −40° F. Special compounds may be necessary for use at lower operating temperatures.

Is it possible to replace another gasket material with cork-and-rubber and thus cut production time?

Yes. In a metal-to-metal joint, for example, flange faces are finished to the tolerances demanded by the assembly. The gasket and gasket channel, however, need not be held to close tolerances if a compressible gasket is used. A slightly oversized cork-and-rubber seal, square or rectangular in cross-section, distorts to the shape of the channel, compresses fully, and allows perfect mating of the flanges. It eliminates the need for either a relief for side-flow or its alternative, a molded gasket.

How well does cork-and-rubber resist fatigue?

Armstrong's Cork-and-Rubber Compositions have excellent resistance to fatigue. This, combined with their reduced tendency to cold flow, makes them ideal for applications in which joints are subject to frequent opening and resealing in the field.

How effective is cork-and-rubber in sealing stampings?

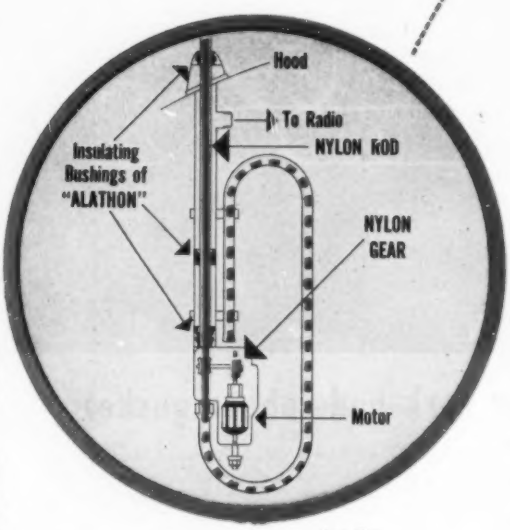
In the drawing above, a cork-and-rubber gasket is used to seal a stamped diesel hand hole cover. The composition compresses easily into the irregularities of the stamping. At the same time, it is impervious and sufficiently resilient to form an effective seal under light bolt pressures.

There is an Armstrong Composition designed to meet each of the six grades in MIL-G-6183 (formerly AN-G-32) covering cork-and-rubber gasketing materials. In addition, Armstrong's research laboratories are ready to develop new cork-and-rubber materials for applications for which no suitable material may be available.

For further information on Armstrong's Cork-and-Rubber Compositions and their application, call your Armstrong representative or refer to Armstrong's Gasket Materials Manual in Sweet's file for product designers. For a personal copy of this manual, write to the Armstrong Cork Company, Gaskets and Packings Department, 7106 Arch St., Lancaster, Pa.

ARMSTRONG'S *Gasket Materials*

Du Pont NYLON plastic drives new automatic antenna



When driver pushes button, motor-driven worm gear turns nylon gears, which turn spring-loaded pulleys. Nylon rod is driven up by pulleys, forcing "live" members upward. Rod coils into trombone-like shape (dotted line) when antenna is lowered. Insulating bushings are made of Du Pont "Alathon"* polythene resin, an outstanding high-frequency insulating material. *TRADE MARK

Only nylon meets mechanical and electrical requirements for Packard antenna

When the Casco Products Corp., Bridgeport, Conn., designed this new motor-driven antenna for Packard automobiles, plans called for a 4½-foot flexible rod to raise and lower "live" members. This strip had to have an unusual combination of properties. Most important of these: it had to be rigid enough to force the antenna up and down, yet flexible enough to fold into a trombone-like position when the antenna is down; and the rod had to have good dielectric properties.

Only Du Pont nylon plastic was found to have all of the properties required. The nylon driving rod has excellent mechanical strength and very low deformation under load, yet is flexible even at extremely low temperatures. The curvature in the trombone-like position has a 4-inch radius, and the nylon rod, while rigid enough to raise and lower the antenna, still takes sharp curves easily. And nylon's electrical properties meet the requirements of the application.

In addition, two nylon gears engage a steel worm gear which is an extension of the armature shaft. They're molded directly onto the shafts to which driving pulleys are attached. The nylon gears are quiet and long-lasting. Both rod and gears have been subjected to as many as 80,000 cycles—many times more than they could possibly be called on to withstand during the life of any car. Neither shows any sign of wear.

Versatile nylon plastic may help *you* develop a better product or process. Demand for nylon currently exceeds supply. However, we suggest you investigate the properties of nylon for future application. We will gladly discuss the availability of quantities for development work. For additional information on nylon and other Du Pont plastics, write:

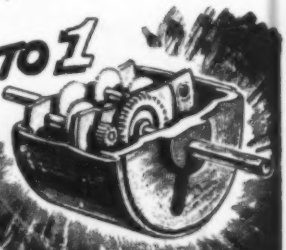
E. I. du Pont de Nemours & Co. (Inc.),
Polychemicals Department, District Offices:
350 Fifth Avenue, New York 1, New York
7 South Dearborn Street, Chicago 3, Illinois
845 East 60th Street, Los Angeles 1, California

DU PONT
REG. U.S. PAT. OFF.
PLASTICS
Better Things for Better Living
. . . through Chemistry

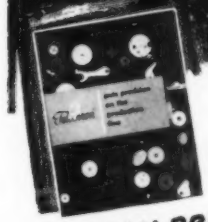
Do You Know?

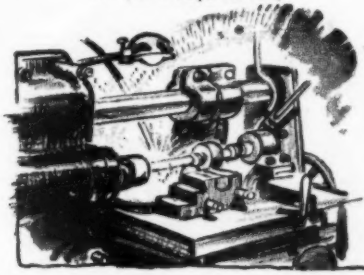
YOU CAN CHANGE SPEEDS
IN A RATIO OF 7200:1 IN A SPACE OF ABOUT 2 CU. IN. WITH A **TELECHRON** SEALED, SELF-OILING GEAR TRAIN... IF YOUR OUTPUT SHAFT LOAD DOES NOT EXCEED .375 POUND INCHES?

216,000 TO 1



SPECIAL GEAR TRAINS
CAN BE MADE BY **TELECHRON INC.** IN A WIDE CHOICE OF SPEED RATIOS UP TO 216,000:1?

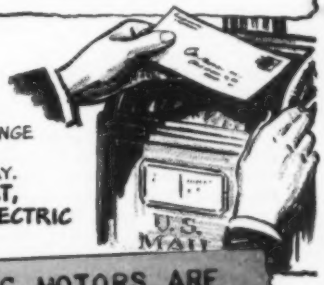




ALL TELECHRON SPUR GEARS ARE HOBBED...
NOT STAMPED... FOR TRUER, QUIETER OPERATION AND LONGER LIFE?

YOU CAN BREAK BOTTLENECKS
ON YOUR DEFENSE CONTRACTS BY CALLING IN **TELECHRON INC.** NEW BROCHURE "PRECISION ON THE PRODUCTION LINE" GIVES A QUICK PICTURE OF PERSONNEL CAPABILITIES AND MASS PRODUCTION FACILITIES. WRITE FOR YOUR COPY TODAY.

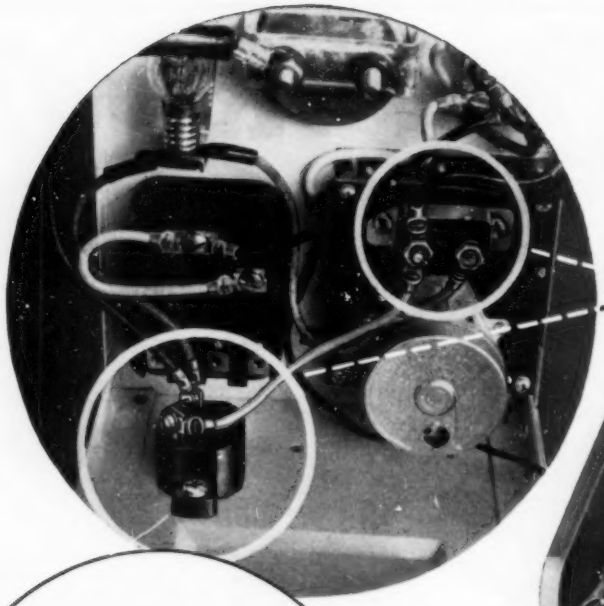
BY RETURN MAIL,
YOU CAN GET DATA AND ESTIMATED QUANTITY PRICES ON **TELECHRON** GEAR TRAINS IN STANDARD SPEED-CHANGE RATIOS RANGING FROM 7200:1 TO 25:1. WRITE FOR THE FACTS TODAY. **TELECHRON INC. 16 UNION STREET, ASHLAND, MASS. A GENERAL ELECTRIC AFFILIATE.**

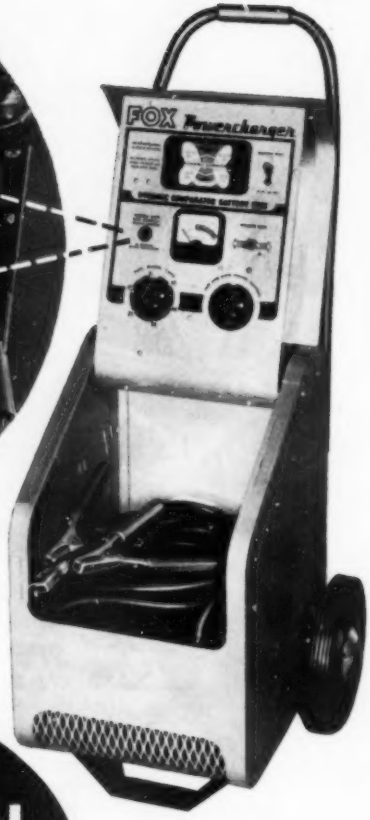


Telechron®

ALL TELECHRON TIMING MOTORS ARE

INSTANTLY...CONSTANTLY SYNCHRONOUS





FOX "Powerchargers"

Get Complete Circuit Protection with —

KLIXON CIRCUIT BREAKERS

Fox "Powercharger" battery chargers make charging automatic, fast, foolproof and trouble free. To protect circuits and batteries, Fox engineers incorporate two Klixon Circuit Breakers into the "Powercharger." The reason, their experience proves that Klixon Breakers can be depended upon to provide positive protection for the full life of the unit. Should the clamps be reversed, shorts occur or if the current is too high, the Klixon Circuit Breakers cut "off" the power and a red light flashes "on": thus preventing possible damage to charger or batteries.

Regardless of the type of electrical equipment you manufacture, it will pay you to use Klixon Circuit Breakers in your products.

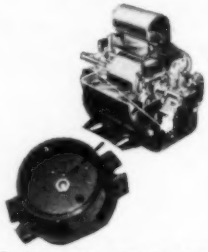
KLIXON

SPENCER THERMOSTAT

Division of Metals & Controls Corp.

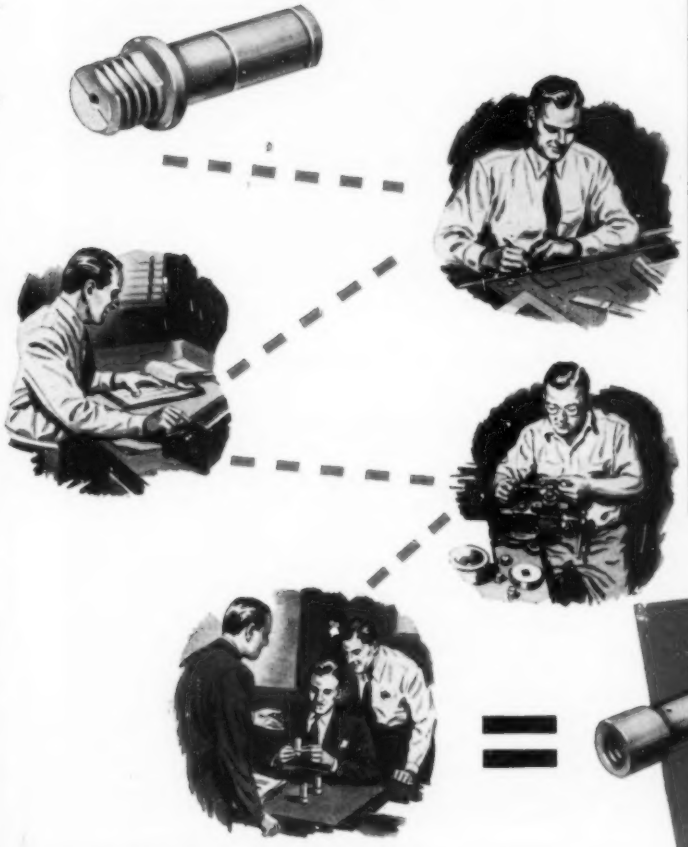
906 FOREST ST., ATTLEBORO, MASS.

KLIXON
MOTOR PROTECTORS
PREVENT MOTOR BURNOUTS



To keep motors operating longer specify and use motors with built-in Klixon Protectors. Should a motor become overheated, the Klixon Protector snaps the power "off," preventing a motor burnout. When it cools to safety, the protector snaps the power "on" automatically if the automatic reset is specified . . . or by pushing the red button when the manual reset type is used.

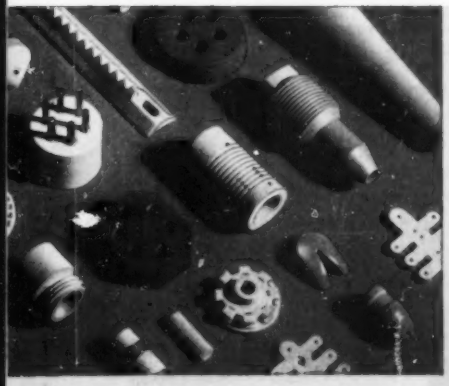
It's a fact that



✔ Very few customers object to our suggestions on redesign. For those who object, we make their designs exactly as they want them. Most customers appreciate the close cooperation given and gladly use our fifty years of specialized experience.

Here are the reasons:

1. *Makes best use of favorable ceramic characteristics, avoids misapplication.*
2. *Designs are kept within practical manufacturing limits.*
3. *Subsequent assembly operations frequently are speeded.*
4. *Several components can sometimes be combined into one.*
5. *Maximum economy.*



Diversified equipment which is far beyond the reach of the average ceramic manufacturer permits us to use the best production method for the job.

Illustrated is a redesign which saved about 60% in original price, saved assembly time, and gave improved performance. Our engineers and production men will make recommendations on request. Send blue prints or samples with data on operating conditions and tolerance requirements. By working together we can serve you better.

AMERICAN LAVA CORPORATION

50TH YEAR OF CERAMIC LEADERSHIP

CHATTANOOGA 5, TENNESSEE

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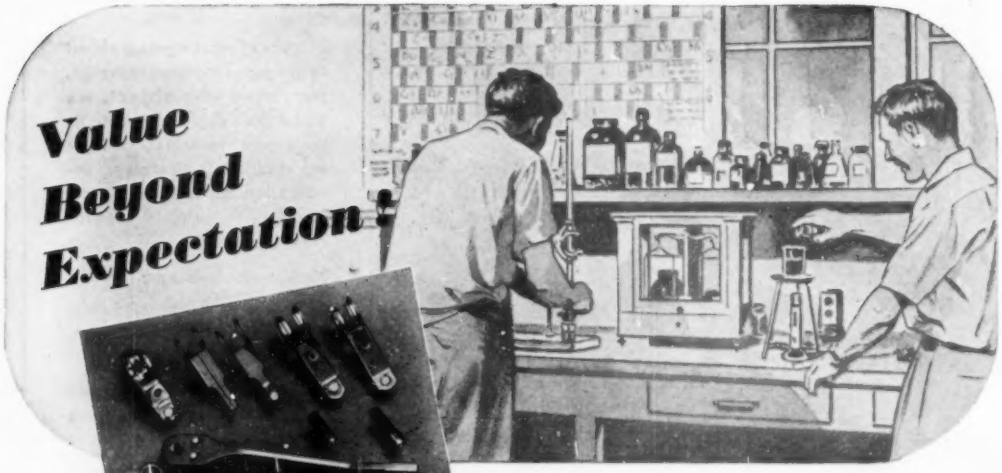
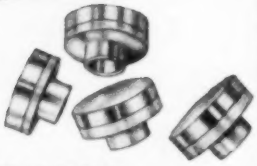
NEW ENGLAND, 38-B Brattle St., Cambridge, Mass., Kirkland 7-4498 • ST. LOUIS, 1123 Washington Ave., Garfield 4959

Value Beyond Expectation





MALLORY TUNGSTEN CONTACTS

Although all Mallory tungsten is chemically the same, the size, shape and distribution of the grain particles are carefully controlled, since these factors vitally affect its electrical and mechanical properties. Mallory will gladly work with you to find the right contacts to meet your specifications. Write today.

Mallory Contact Finish *Brings Laboratory Standards To Production Operations*

The Mallory "E-Treat" finish is one of the many ways in which Mallory metallurgical developments are improving performance and reducing costs of electrical contacts.

A typical example is the real help provided by Mallory for a manufacturer of automotive equipment who faced the problem of excessive failures of tungsten contacts. The application involved a critically heavy electrical load with light contact pressure. Mallory contacts with "E-Treat" finish . . . a chemically pure, highly polished face . . . were tested and enthusiastically approved. The "E-Treat" finish afforded lower contact resistance and less material transfer . . . tripled the minimum contact life. What is more, the Mallory contacts *cost less* than those formerly used!

That's value beyond expectation!

Mallory contact know-how is at your disposal. What Mallory has done for others can be done for you!

In Canada, made and sold by Johnson Matthey and Mallory, Ltd., 110 Industry St., Toronto 15, Ontario

Electrical Contacts and Contact Assemblies

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

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Resistors *Switches*
TV Tuners *Vibrators*

Electrochemical Products
Capacitors *Rectifiers*
Mercury Dry Batteries

Metallurgical Products
Contacts *Special Metals*
Welding Materials

LINK-BELT Ball and Roller Bearings smooth the path of power

Lubrication fitting with pressure relief feature prevents excessive grease pressure.
The "housing sealed" feature fully protects and lubricates all moving surfaces.
Self-aligning—inner raceway is truly spherical, free to move in any direction without altering contact area with rollers. Full load capacity always assured with shaft deflection or misalignment.
Large grease reservoir prolongs lubrication intervals.
Sturdy, compact cast housing requires minimum support space.
Threaded end cover with two set-screws and fibre locking inserts holds bearing firmly in housing.
Long inner ring distributes bearing load over large shaft area.
Easily installed by slipping bearing onto shaft and clamping inner ring by tightening two set screws in spring locking collar.
Seals effectively keep grease in, dirt out.
Slotted bolt holes facilitate mounting on supporting structure.
CUTAWAY OF SERIES 400 ROLLER BEARING PILLOW BLOCK

By any standard . . . **LINK-BELT Bearing Blocks offer strength plus economy**

POUND-FOR-POUND you can't beat the bearing strength and long life of Link-Belt Ball and Roller Bearings. Take the Series 400 Roller Bearing Pillow Block, for example. Built for shaft sizes from ¾ to 4 in., this bearing has an "average life" up to 100,000 hours . . . radial load ratings up to 61,000 pounds. A Link-Belt bearing specialist will help you apply any of the broad Link-Belt line. And you'll find complete engineering information in Data Book 2550.

LINK-BELT

BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in principal cities. 12,430

Plastics Check list

A useful summary of the current situation... for designers or engineers who are planning to "do it with plastics"

Planes fly . . .

Ships sail . . .

Motors run . . .

. . . with *plastics* serving in vital spots. Plastics serve the nation's defense in countless, all-important ways. USE THEM WISELY!

As the pressures for more production increase . . . as the shortages of materials, labor, and power grow more critical . . . someone in your organization is almost sure to ask you, *"Why not use plastics?"* It's a good suggestion. In many instances plastics have replaced other materials because of their superior advantages for certain applications. But whatever *your* company manufactures, whatever the specific materials problems *you* might hope to solve with plastics, the following facts should be kept in mind:

- ✓ **Today plastics are essential materials.**—Because of their versatility, their adaptability to volume production, their economy of time, labor, and power—plastics are basic raw materials in their own right—of vital importance to defense industry.
- ✓ **Many plastics are already in short supply.** Monsanto and other materials producers are expanding output as rapidly as the basic chemicals become available, but essential applications will probably continue to take most of the plastics supply.
- ✓ **Plastics must be used correctly.** Like any other material, they have their limitations. And what is a sound application for one plastic may be entirely impractical for another.

We suggest that you send your materials engineering questions about plastics to the Monsanto Plastics Technical Council. This Council, composed of technical experts on every material in the industry's biggest family of plastics, will study your design and/or materials problems and make recommendations. Or, if you prefer, get in touch with the nearest Monsanto sales office.

MONSANTO CHEMICAL COMPANY
Plastics Division, Springfield 2, Mass.

The big MONSANTO *family of plastics*

SERVING INDUSTRY . . . WHICH SERVES MANKIND

GET YOUR FREE COPY NOW

of this authoritative, fact-filled bulletin on "What to Consider When Selecting A Metallic Bellows"

What to Consider When Selecting a Metallic Bellows

CLIFFORD

Contains: • **Charts** • **Diagrams** • **Applications** • **Detailed analysis of bellows' construction, materials, flexibility, filling medium, life**

Are there 3, 8, 10 or 14 common types of bellows and methods of attaching end fittings available to you when you consider bellows for the job you have in mind? Is stainless steel, nickel or brass the material most frequently used? What affects the choice of material? How can you double the flexibility and halve the spring rate of a bellows? How can you limit the total pressure generated by a bellows at a specified temperature? What are the advantages of a bellows shaft seal? What determines the motion relationship between two or more bellows when they are connected together?

These and many other questions are answered in the informative bulletin "What to Consider When Selecting A Metallic Bellows," featuring an authoritative article which has appeared in a recent issue of PRODUCT ENGINEERING. Written by engineers at Clifford Manufacturing Company, bulletin contains a wealth of up-to-the-minute data on bellows.

Send for your free copy today. Just mail coupon below.

Clifford Manufacturing Company, Waltham 54, Mass. Div. of Standard-Thomson Corp. Sales offices in New York, Detroit, Chicago, Los Angeles.

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FREE **Please send me my copy of the bulletin "What to Consider When Selecting a Metallic Bellows." I am interested in the applications checked.**

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- ☐ Heating equipment
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- ☐ Remote or direct control of temperature and pressure
- ☐ Electric or gas ranges
- ☐ Kilns & ovens — industrial
- ☐ Air compressors
- ☐ Oxygen flow indicators
- ☐ Oxygen regulators
- ☐ Process controls
- ☐ Refrigerating systems — commercial
- ☐ Shaft seal assemblies
- ☐ Fuel pumps
- ☐ Fluid couplings
- ☐ Supercharger controls
- ☐ Refrigerator controls — domestic
- ☐ Torque converters
- ☐ Compensating regulators

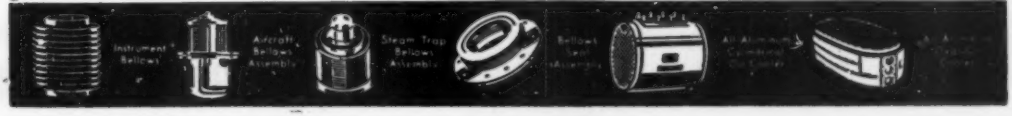
Other applications .....

Name ..... Title .....

Firm .....

Street .....

City ..... Zone ..... State .....



TEN TIMES THE LIFE AND STILL GOING STRONG!

Ni-Hard† Pipe Proves Superiority in Resisting Abrasive Action

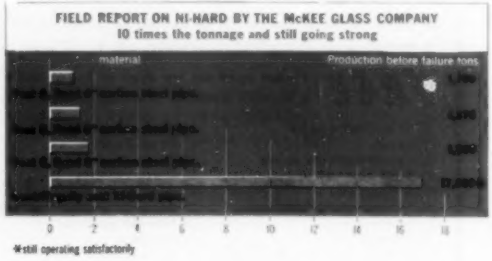
If your problem is abrasion, you'll be interested in this case history of Metal Mold centrifugally cast Ni-Hard pipe in action.

The McKee Glass Company, one of the nation's leading producers of molded glass for household and industry, uses a pneumatic conveyor system to handle its glass furnace charges. In this system tons of silica, sand, feldspar, borax, etc., are hurled at tornado-like speeds . . . about 100 miles per hour . . . through vacuum lines from boxcars to storage bins. Broken glass scrap (cullet) is added at the mixers to form a highly abrasive mixture.

Two years ago when the system was installed steel piping and later, lined steel piping was used. The severe abrasive action coupled with serious discoloration of the glass led to the search for a better conveying material. As a result, Metal Mold centrifugally cast plain end Ni-Hard pipe with a Brinell hardness of 600-650 was installed in the line's most abrasive sections.

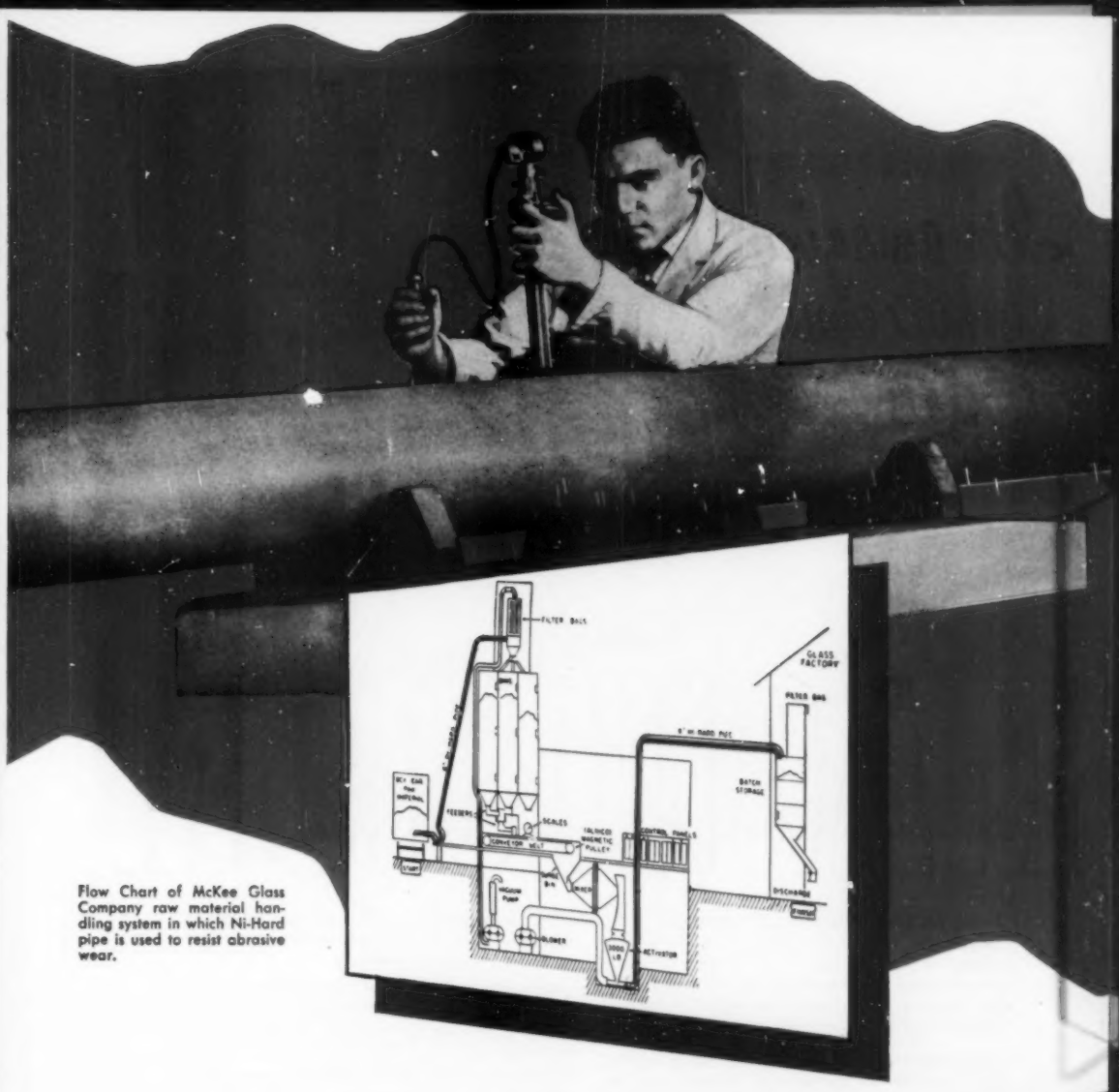
The result, as reported by McKee, was more than satisfactory. Contamination was reduced 80%. Ni-Hard resisted abrasion much more effectively, as shown by the chart below . . . thus far, in fact, has carried *ten times the tonnage and the line is still going strong!*

Today, the McKee Glass Company uses Ni-Hard exclusively in its conveying system. Their experience may suggest the answer to *your* abrasion problem.



†Nickel-chromium white cast iron.
Ni-Hard is a registered trade name of The International Nickel Co., Inc.

U. S. PIPE AND
SPECIAL PRODUCTS DIVISION
AMERICA'S LARGEST PRODUCER OF CENTRIFUGUALLY



Flow Chart of McKee Glass Company raw material handling system in which Ni-Hard pipe is used to resist abrasive wear.

FOUNDRY CO.

BURLINGTON, N. J.

CAST FERROUS METAL PRODUCTS IN TUBULAR FORM

TYPES OF METAL CAST

Stainless Steel—All AISI Types, plus special heat and corrosion resistant analysis.

Alloy Steel—all grades.

Carbon Steel—all grades.

Gray and Alloy Iron—all standard and special analyses, including Ni-Hard and Ni-Resist.

"Duplex Metal"—Gray or alloy iron inside steel, gray iron inside chilled iron, and tool steel, iron or steel inside stainless and many other metallurgically bonded two-metal centrifugally cast combinations.

SIZE RANGE

Outside diameters—3½" through 30". Wall Thickness—¼" to 4". Lengths—Up to 14'.

It's amazing what you can do

in one draw...

MAGNESIUM

Designers and production men, unfamiliar with magnesium, are usually surprised at the drawability of the material. While it isn't quite so easy to draw as pictured above, the practice of hot forming magnesium does permit deformations seldom possible in any other metal.

Generally speaking, magnesium alloys can be hot drawn in one operation to a depth equal to 80% reduction in blank size. This often eliminates the need for multiple stage dies, speeds up the operation, and reduces processing costs even though preheating of the sheet and dies is required. Since hot forming is used, spring-back problems are greatly reduced.

Almost any press found in the ordinary press shop can be used to draw magnesium, although hydraulic presses are preferred when the draw is severe and controlled speeds are required. Dies are similar to those used on other metals.

For additional information on drawing or forming magnesium, call your nearest Dow sales office or write direct.

Magnesium Division, Dept. MG-121

THE DOW CHEMICAL COMPANY
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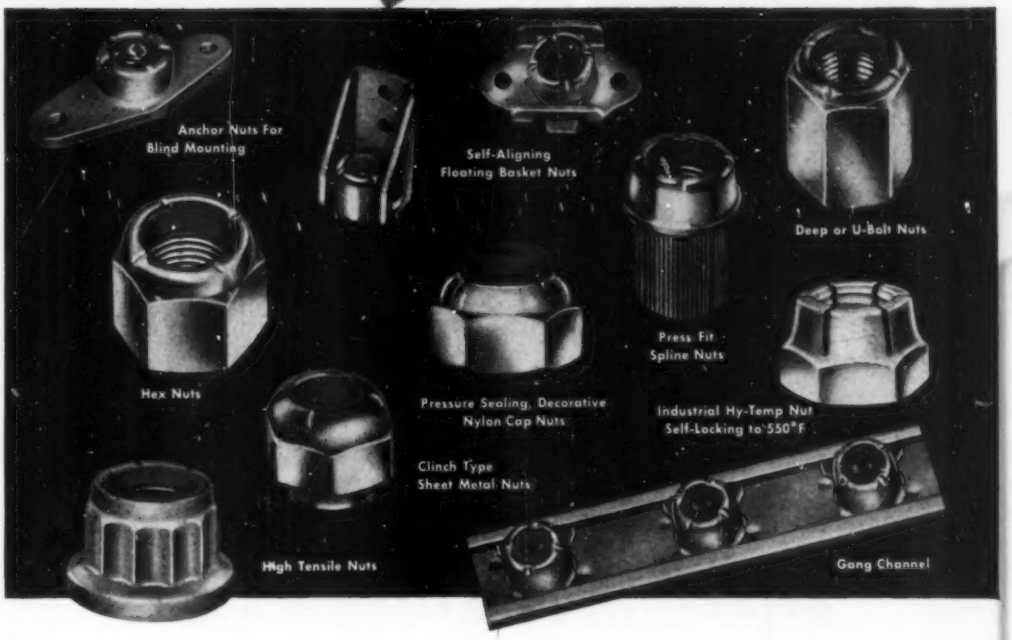
ESNA *Self-Locking* FASTENERS


Anchor Nuts For Blind Mounting
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Deep or U-Bolt Nuts
Press Fit Spline Nuts
Hex Nuts
Pressure Sealing, Decorative Nylon Cap Nuts
Industrial Hy-Temp Nut Self-Locking to 550°F
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Gang Channel

3011 ways to solve your Fastening Problems

When fastening problems come up, are you ready with an immediate answer? Or, do you find that many of your problems are major design jobs?

If fastening presents any problem at all, Elastic Stop Nuts can supply the answer fast. In stock, ready for delivery to you when you say the word, ESNA has 453 off-the-shelf answers to your problems. Tooled for production, ESNA has 2558 more.

Yes, 3011 types and sizes of Elastic Stop Nuts cover just about every fastening job you run into. And the self-locking action of the Red Elastic Collar is your guarantee of performance. For instance, when you want to pre-stress a bolt to insure proper load distribution; or if you must "set" and maintain an exact spring-loaded adjustment; the torque provided by the grip of the Red Elastic Collar on bolt threads, will do the job. When you've got to have a fastener with a locking hold that can't be shaken loose by the toughest mechanical or operating vibration, the answer is an Elastic Stop Nut. If you need a fastener that will protect internal bolt threads against corrosion and assure easier repair jobs . . . the moisture seal and guarantee of reusability provided by the Red Elastic Collar means that your fastener is an Elastic Stop Nut.

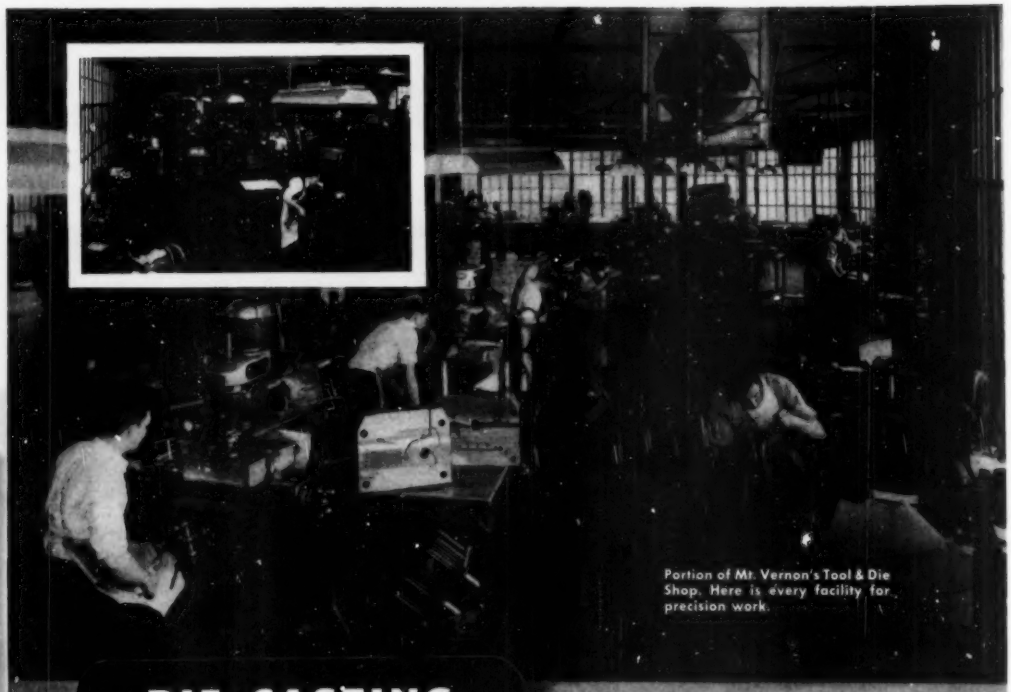
Problems like yours are solved at ESNA day after day—and have been since 1927. In the railroad industry, in the oil fields, in automobiles, aircraft, and construction projects, reusable, precision-setting Elastic Stop Nuts are doing the kind of fastening job you're looking for.

If your problem is a common one, ESNA will supply one of the 3011 types of Elastic Stop Nuts immediately. If you need a special design, ESNA will make quick work of your problem by handling both design and manufacture. Why not get ready to handle that next fastening problem now? Send details of your problem, or write asking for a call from an ESNA engineer. For the new ESNA catalog, write Elastic Stop Nut Corporation of America, Union, N. J.

ESNA

ELASTIC STOP NUTS

HIGH TENSILE · ANCHOR · HIGH TEMPERATURE · SPLINE · CLINCH · GANG CHANNEL · NYLON CAP



Portion of Mt. Vernon's Tool & Die Shop. Here is every facility for precision work.

DIE CASTING

Dependability is Assured here!

At Mount Vernon, we have completely coordinated designing, engineering and die building facilities *under one roof.* The activities of our modern and extensive die shop are closely integrated with those of other departments, with the result that long-life, accurate dies—yielding clean, flawless castings—are assured.

When considering a manufacturing procedure, therefore, remember not only the outstanding economies inherent in die casting, but also

Mount Vernon's Complete Four-Fold Service

(1) Consultation — M. V. can help you with design and production problems by making recommendations based upon your specific requirements.

(2) Die Making — M. V's up-to-the-minute tool and die shop equipment, plus long experience and highly skilled personnel, assure a dependable source for quality dies.

(3) Castings — M. V. castings, meeting ADCI standards, are guaranteed "on grade" at all times.

(4) Machining — M.V. machining facilities can handle every machining operation that castings may require.

We shall welcome the opportunity to serve, and assist you—as we have assisted many others—to increase your output, improve your products, and *hold down your production costs.*

MT. VERNON
DIE CASTING CORP.
MT. VERNON, NEW YORK

SYLPHON CONTROLS FOR DEPENDABILITY

NEW!

SYLPHON No. 999 temperature regulator

MORE POWERFUL • STAINLESS STEEL FRAME FOR MINIMUM HEAT CONDUCTION • LESS HEIGHT AND WEIGHT • LARGE SIZE, 2-PLY SYLPHON BELLOWS FOR ADDED POWER • SELF-OPERATING

THIS NEW ADDITION to the Sylphon line is highly recommended for all industrial processes requiring accurate, dependable temperature control. Particularly suited for storage water heaters . . . metal plating tanks . . . bottle washers . . . treaters . . . slashers . . . etc.

Like all Sylphon regulators, No. 999 is self-powered. It requires no compressed air or other auxiliary power source. It's ideal as standard equipment. Thoroughly dependable. Simple and compact. Sturdily built for long service life.

Also available with fin type bulb for controlling temperature of air or gases. Other models: 999-A has over temperature protection; 999-T equipped with dial indicating thermometer. Write for complete details. Ask for Catalog LP.

FS FIRST WITH BELLOWS

Temperature Controls • Bellows Devices • Bellows Assemblies

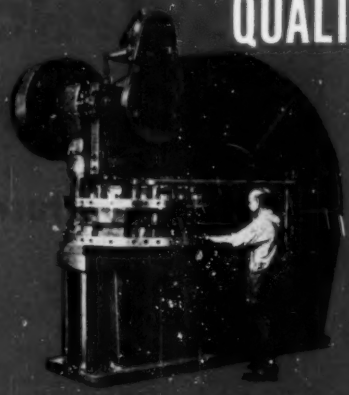
FULTON SYLPHON DIVISION

ROBERTSHAW-FULTON CONTROLS CO. KNOXVILLE 4, TENN.

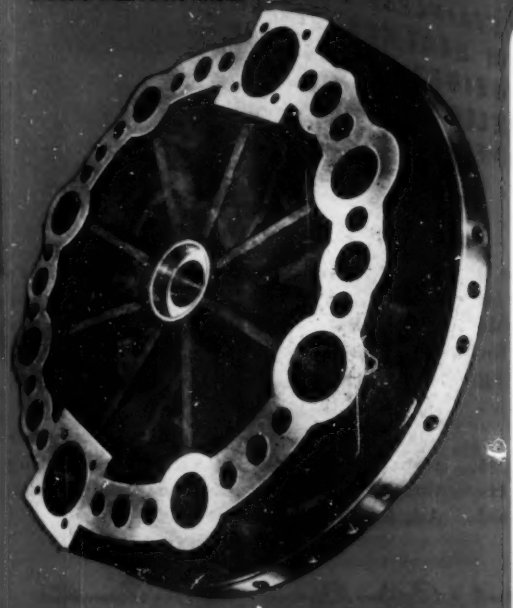
Canadian Representatives, Darling Brothers, Montreal

NEEDED—

STRENGTH, DENSITY, MACHINABILITY, QUALITY



Type R-7, 80 ton Wiedemann turret punch press with 54" diameter MEEHANITE turret.



Upper Turret Casting for Type R-7 Wiedemann Turret Punch Press. The outside Diameter is 52". The Weight is 2900 lbs. Because the Turrets in Type R-7 Wiedemann Presses must Have Great Strength, Fine Machinability and be Non-Porous, MEEHANITE CASTINGS are used for these parts.

SUPPLIED BY—

MEEHANITE® CASTINGS

In the manufacture of heavy-duty equipment, Wiedemann Machine Company, Philadelphia, Pa., outlined their requirements as designated above. Upon reviewing these needs as fundamental in the design of certain components of their products, Wiedemann engineers specified Meehanite castings for the turrets and many smaller castings in their line of turret punch presses. Both the press and a close-up view of the Meehanite upper turret casting are shown.

This is another example of the superior engineering properties and recognized quality of Meehanite castings meeting important manufacturing needs. Meehanite means better castings, so whenever you need *better* castings, consult your Meehanite foundry first.

Write for our new sound slide film entitled "Meehanite Castings Serve all Industry," a fast-moving, 30-minute record of Meehanite casting applications.

WHEN YOU NEED "EXTRAS" IN QUALITY OR PROPERTIES CONSULT ANY OF THE FOUNDRIES LISTED BELOW

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Bonnar Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry	Providence, Rhode Island
Continental Gin Co.	Birmingham, Alabama
Crawford & Doherty Foundry Co.	Portland, Oregon
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
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General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Lincoln Foundry Corp.	Los Angeles, California
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Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
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Smooth, trouble-free operation and better power transmission are assured with Foote Bros. Hygrade Heavy-Duty Worm Gear Drives.

New developments in manufacturing provide precision generated gears which give improved performance and greater load-carrying capacity.

Advanced engineering, improved design, modern heat treatment and manufacture — all mean higher quality — greater dependability.

Hygrade Drives with ratios up to 4108 to 1, or higher when required, are available in horizontal, vertical and Hytop types. The Hytop design permits long, unsupported vertical output shaft extensions.

Mail the coupon below for bulletin giving complete information on Foote Bros. Hygrade Enclosed Worm Gear Drives.

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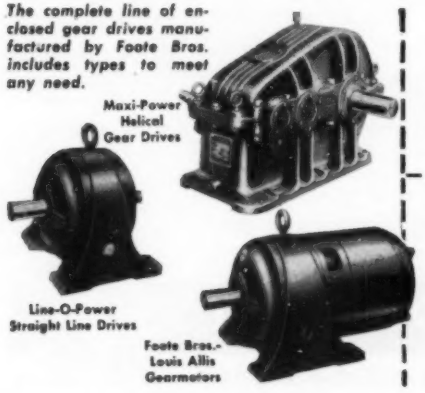
The complete line of enclosed gear drives manufactured by Foote Bros. includes types to meet any need.



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Better Power Transmission Through Better Gears

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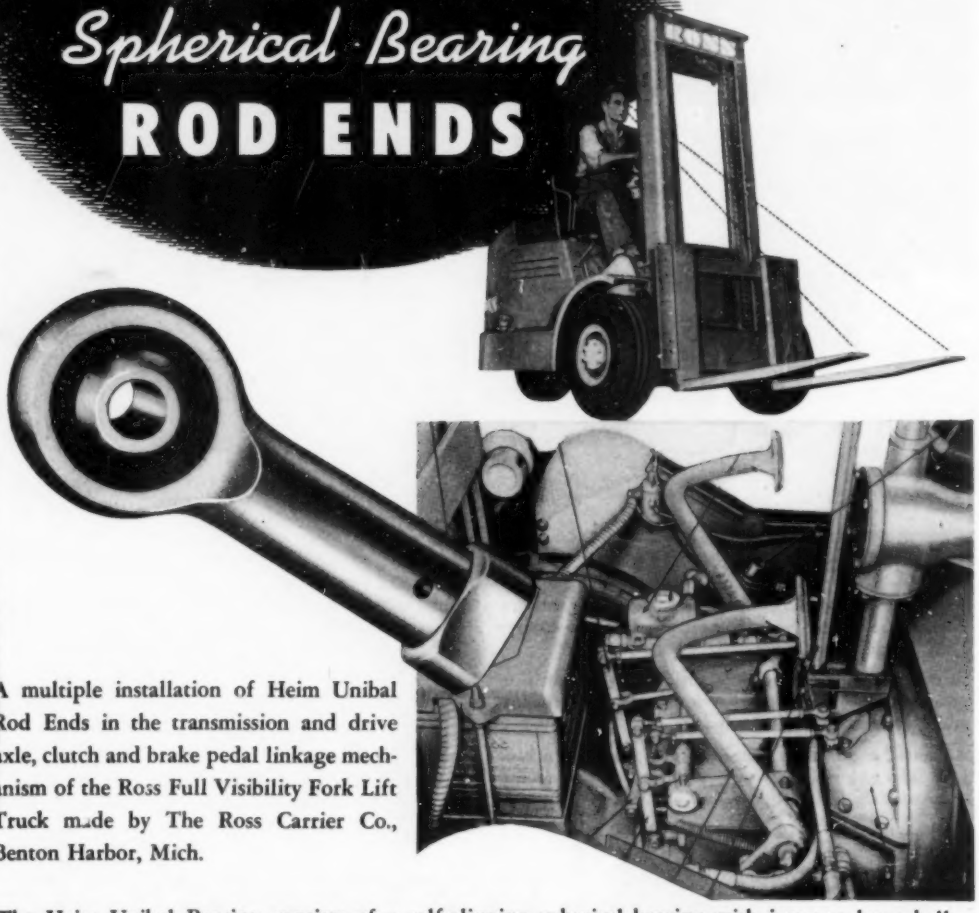
HEIM

Spherical Bearing

ROD ENDS



A multiple installation of Heim Unibal Rod Ends in the transmission and drive axle, clutch and brake pedal linkage mechanism of the Ross Full Visibility Fork Lift Truck made by The Ross Carrier Co., Benton Harbor, Mich.

The Heim Unibal Bearing consists of a self-aligning spherical bearing with just one large ball rotating within a bronze bearing race. Carries heavy radial and thrust loads, and corrects misalignment in all directions.

Distributors in principle cities.

Complete catalog of Rod Ends and Bearings on request.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

Aluminum

Government regulations limit the use of aluminum for other than essential products. The facts presented here are to help you speed this essential work and get the most out of available metal.

becomes increasingly important to designers as they help America rearm. Alcoa presents useful information on its properties, available forms and production economies.

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Aluminum Fasteners
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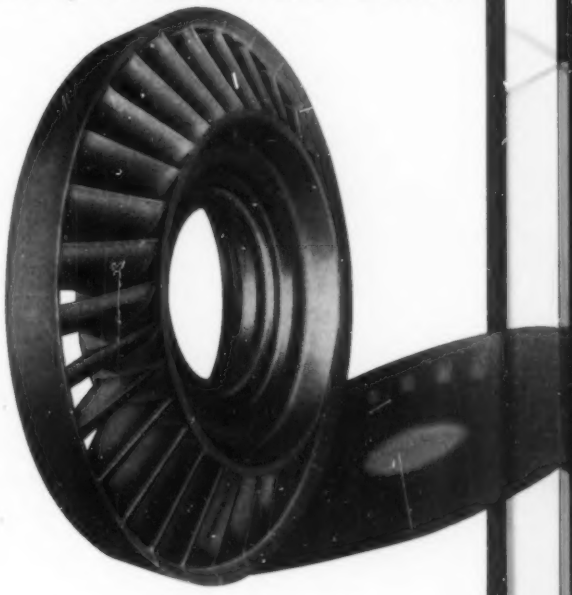
Aluminum Extrusions



Aluminum Castings

Plaster molding, as practiced in Alcoa Foundries, offers designers important advantages in accuracy of parts, less finishing and machining.

For medium quantities, plaster castings offer definite advantages over sand, permanent mold and die castings. Surfaces are far smoother than sand castings — usually requiring very little or no finishing. While molding costs are higher than sand casting, Alcoa's production facilities make the per-part price usually lower than die or permanent mold castings for medium-length runs.

Thin sections can be cast in plaster molds. Dimensional tolerances of .005 per inch can be held easily. Machining usually can be held to an absolute minimum.

Alcoa Foundries currently produce automotive torque converters, impellers and aircraft accessory fittings by the plaster process. And since Alcoa casts both aluminum and magnesium by all methods, our specialists are in an excellent position to make totally unbiased recommendations of the process best suited to your particular part and quantity.

ALCOA

ALUMINUM COMPANY OF AMERICA • 1807F GULF BLDG., PITTSBURGH, PA.

Aluminum Die Castings

often cost less than die castings of any other metal. Their physical and mechanical properties suggest them for many rearmament jobs.

Aluminum's lighter weight permits more than twice as many castings per pound as heavier metals. The cost-weight ratio operates favorably in so many cases that economies are possible even in small castings. Exceptionally large die castings as produced by Alcoa are almost certain to cost less in aluminum.

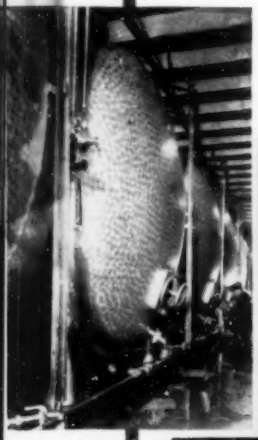
Alcoa Aluminum die castings offer substantial physical property advantages. Stability of dimensions through a wide temperature range and under sustained loads. High conductivity of heat and electricity. All of these advantages cannot be matched by other die-casting metals.

Examination of shop costs show other advantages of Alcoa Aluminum die castings. Machining is fast. Speeds and feeds are usually limited only by the capacity of the machine tools. Handling and shipping cost less.

These and other design considerations are covered in detail in Alcoa's 188-page designers' handbook, "Designing for Alcoa Die Castings." Write for your free copy.

Finishing Aluminum

While all finishing methods may be used, these simple mechanical methods require no large investments in equipment.



While most mechanical finishes are used for decorative effect, some have functional purposes. Preparing the surface for greater paint adhesion and increasing aluminum's reflectivity of light and radiant heat are examples of the latter. Any mechanical finish that can be applied to other metals can be applied to aluminum.

Buffing — Highly specular surfaces can be imparted to aluminum by simple buffing and coloring operations.

Scratch brushing — Soft, satiny effects can be achieved by using wire brushes of varying stiffness and metal hardness. Such finishes are used to increase aluminum's heat absorbing properties and to relieve the monotony of large areas.

Sand blasting — An easy method to produce a uniform, soft sheen to aluminum — to hide minor surface defects — to produce interesting high-light effects by masking.

Tumbling and burnishing — An extremely economical method for mass finishing of small parts. Ball burnishing produces smooth, lustrous surfaces.

All finishes for aluminum — chemical, electrochemical, painted and anodized — are described in detail in Alcoa's 63-page book, "Finishes for Alcoa Aluminum." Write for your free copy.

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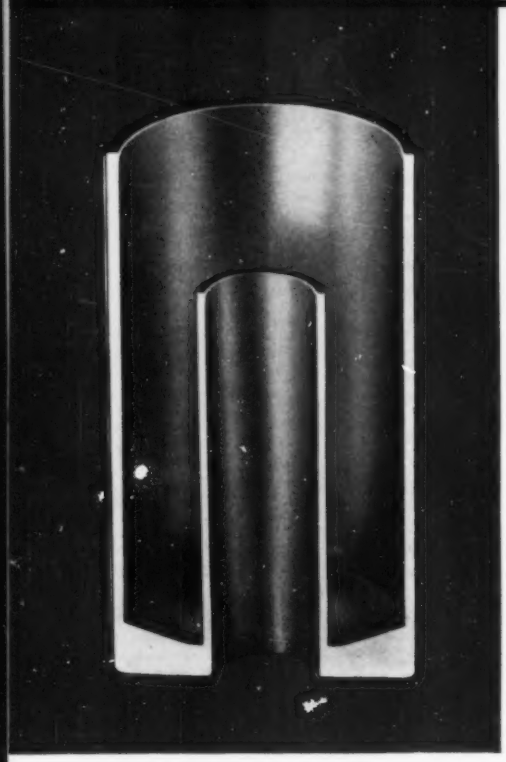


Impact Extrusions

For the first time in the United States, Alcoa is producing double wall impact extrusions. This case history shows the important production savings they offer.

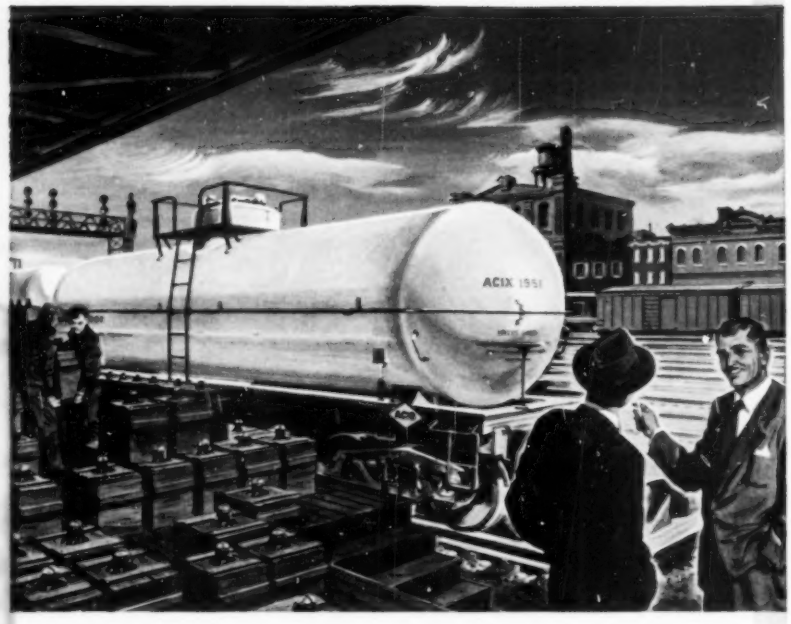
The manufacturer of this Navy signal flare part was faced with a production problem. Heavy investments in cost and time were required to make this product by welding two sections of tubing to an end plate.

Alcoa specialists suggested impact extrusion as a faster, more economical method of production. This process, which forms a cold slug into a hollow, cylindrical shape in an instantaneous press operation, has brought economies to many single wall parts. Alcoa facilities now produce the double wall one-piece part in a single, fast press operation.

Almost any symmetrical cup-shaped or hollow part can be impact extruded — complete with ribs, cavities and integral bosses in thin or heavy walls. If you have such a product that is not easily fabricated, formed or drawn, let Alcoa specialists work with you to explore the possibilities of impact extruding. Write for the free Alcoa book, "Alcoa Aluminum Impact Extrusions."

ALCOA

ALUMINUM COMPANY OF AMERICA • 1807F GULF BLDG., PITTSBURGH, PA.



This car replaced 615 "Bottles"... because a chemical manufacturer asked *"WHY?"*

In 1927 a chemical manufacturer asked us, "Why must some chemicals be handled in small drums or carboys . . . can't tank cars be built of aluminum?"

From research, we knew we had alloys compatible with many chemicals, and our knowledge suggested welding as the fabrication method. But railroad standards and railroad usage dictated months, perhaps years of careful testing. We decided to design and pay for the first aluminum tank car ourselves.

Our engineers designed an 8,000 gallon tank, welded together from 16 aluminum plates. Working with a leading tank car builder, we advised on alloy selection, welding technique and structural fabrication . . . from lessons learned in other Alcoa developments. Completed in 1928, the car was tested in 20,000 miles of service hauling glacial acetic acid, a typically tricky cargo. The car weathered 3,500 recorded shocks—900 severe ones. *That aluminum car is still in service today!*

Tank car builders, working with Alcoa engineers, continued to improve tank cars. Together we developed riveted and welded designs that are now standard. Rolled huge plates, made rivets large enough to join them. Improved welding techniques, structural assembly, alloys. Most recent: a new high-strength, high-purity alloy, permitting thinner sections, saving greatly in material and fabrication.

Over 1,300 aluminum tank cars now carry the fussy compounds that used to travel in small containers . . . because a chemical manufacturer asked, "Why?" Perhaps such a long-range development program, started now, can effect a major change in *your* company's competitive position.

ALCOA

there are no limitations on *Imagineering*

for such

1

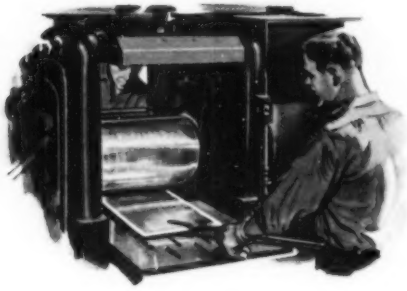
Knowledge and Specialists IN MANY FIELDS

- **Aircraft**
- **Architectural Specialties**
- **Automotive**
  - **Passenger Cars**
  - **Trucks and Trailers**
  - **Buses**
  - **Parts and Accessories**
- **Bearings**
- **Building Industry**
- **Business Machines**
- **Chemical Equipment**
- **Communications**
- **Corrosion Studies**
- **Diesel Engines**
- **Electrical Conductors**
- **Electrical Equipment**
- **Farm Machinery**
- **Food Equipment**
- **Handling, Packaging and Shipping**
- **Hardware**
- **Heat Exchangers**
- **Home Appliances**
- **Instrumentation**
- **Insulation**
- **Marine Industry**
- **Mining Equipment**
- **Paper Machinery**
- **Petroleum**
- **Pressure Vessels**
- **Printing Machinery**
- **Railroad Equipment**
- **Structural Engineering**
- **Textile Machinery**

Among these specialists at the Development Division are men already familiar with the problems of your industry. They are your liaison with the Alcoa research, test and fabricating facilities that can be put to work on your problem. Through them the sum total of Alcoa's knowledge will be brought to bear. Knowledge of practical problems of fabrication and costs, gained in thousands of other projects, will flow toward yours.

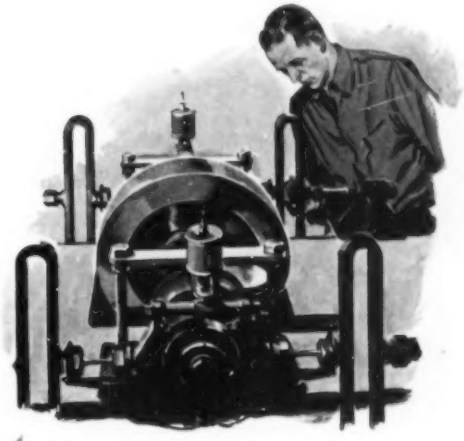
DEVELOPMENT DIVISION

long-range projects we have these to offer:



2 FACILITIES FOR BROAD *Research*

The Aluminum Research Laboratories' experimental mill rolls new alloys into sheet preparatory to physical testing. Basic data on all aluminum alloys is being constantly assembled with the help of facilities ranging from X-ray diffraction to spectographic analysis.



3 ADVANCED *Test* EQUIPMENT

Applying alternating tensile and compressive forces to test your product's fatigue strength provides practical knowledge that can never be computed. Thorough testing on Alcoa's extensive equipment will duplicate years of normal operating conditions.

4 *Process Development Shops* FOR PILOT AND MODEL WORK

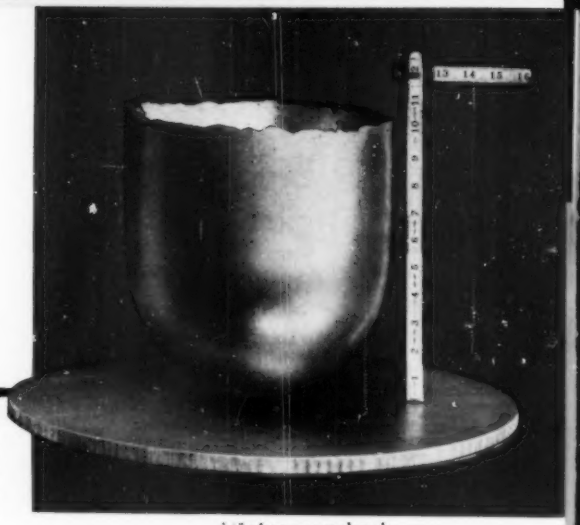
Shielded arc welding, one of Alcoa's continually developing projects, is typical of the techniques we use to develop—if you wish it—a pilot model of your product. Sixty-three years' knowledge of casting, forming, heat-treating, machining and finishing are at your disposal.

ALCOA

For more details on the personnel, research and testing, and shop facilities available at Alcoa, write for your copy of the folder, "Road Map to a Better Product." It is your first step toward putting 63 years of aluminum knowledge to work on a long-term project that may effect a major change in your company's competitive position. Address: ALUMINUM COMPANY OF AMERICA, 2185E Gulf Bldg., Pittsburgh 19, Pa.

Magnesium

Deep, single draws . . . impossible in any other metal of equivalent strength . . . are easily accomplished by hot forming.



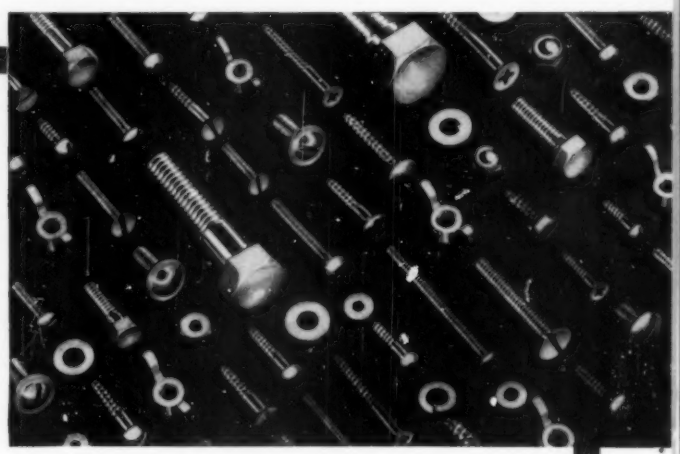
½" plate — one draw!

Reductions in blank size of 40% to 70% are not uncommon in magnesium when the stock and dies are heated. This propeller dome was drawn to a depth of 10" from ½" AMC52S-O in a single operation. The stock and dies were heated to about 600° F.

The production advantages of such deep draws are obvious. Die life is lengthened. Multiple stage dies are eliminated. Press time is cut. Spring-back is greatly reduced, with increased accuracy of parts. Annealing operations are no longer needed, for only one draw is required in most cases. Standard presses, furnaces and dies can be used. Only minor reductions in tensile and yield strengths result from preheating.

Alcoa's free, 329-page book, "Designing with Magnesium," describes deep drawing along with every phase of machining and fabricating. 6 pages of reference — 117 pages of tables — 178 pages of text — many illustrations, charts and diagrams.

Aluminum Fasteners



Both aluminum and non-metallic assemblies benefit from these lowest cost of all corrosion-resistant fasteners.

With more and more aluminum going into defense equipment, designers are becoming acutely aware of the importance of aluminum fasteners. They prevent galvanic corrosion that can occur when fasteners of dissimilar metals are used. They do not corrode from atmosphere or many chemical compounds.

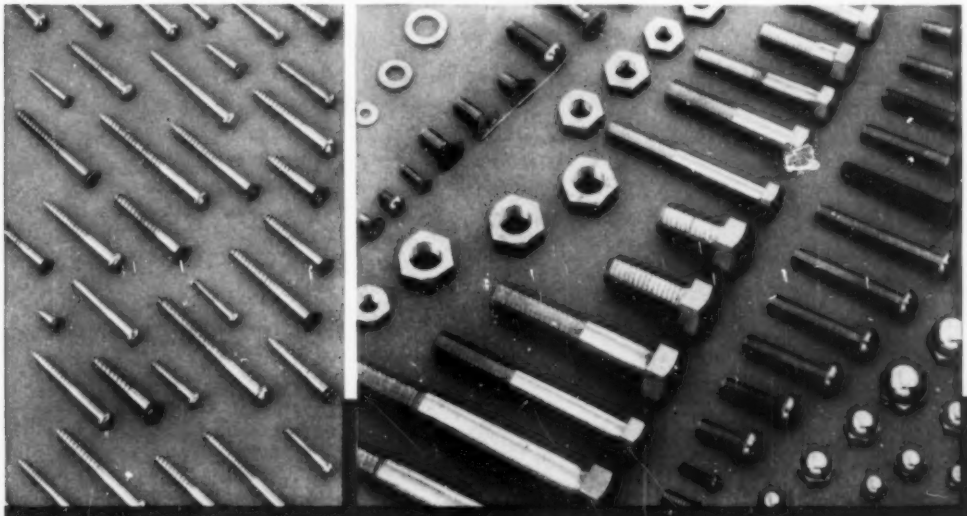
ALCOA

ALUMINUM COMPANY OF AMERICA • 1807F GULF BLDG., PITTSBURGH, PA.

Fasteners (continued)

Alcoa makes a complete line of standard fasteners—can supply special fasteners to meet specific requirements. The Alcoa line includes sheet metal, machine and wood screws with choice of slotted or Phillips recessed heads; bolts and nuts of all standard sizes; cap, castle and wing nuts; washers, rivets and cotter pins.

Alcoa fastening specialists offer design help on questions of alloy selection, rivet driving methods and use of aluminum fasteners with other materials. Alcoa will gladly help you with your fastening problems.



Aluminum Screw Machine Stock

Alcoa has developed free-cutting alloys having high strength, good forming qualities, excellent corrosion resistance.

Rod, wire and bar of Alcoa Aluminum is available in these special alloys to give you a wide range of physical and chemical properties in the finished part.

Some have exceptional resistance to corrosive liquids and gases — are ideal for nozzles, couplings, valves, flanges, inserts, fasteners and similar components of equipment for the process industries.

Others offer higher mechanical strength or faster machining. All can be finished by any commercial method — mechanical, chemical, electrochemical, organic and inorganic coatings and anodizing.

With its 63-year aluminum background, Alcoa is in a unique position to assist designers of aluminum screw machine products in problems of alloy selection. Investigate through any Alcoa sales office, listed under "Aluminum" in your classified phone book.

MAJOR ALLOY PROPERTIES
Alcoa 115-T3 — The best general purpose aluminum alloy for automatic screw machines.
Alcoa 175-T4 — Stronger than 115-T3 . . . best for deep hole drilling.
Alcoa 248-T4 — Stronger than 175-T4 . . . widely used for aircraft and other high-strength applications.
Alcoa 618-T6 — High corrosion resistance . . . especially suited to finishing by anodizing.

ALCOA

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Aluminum Extrusions

permit placement of metal where maximum strength is needed... save greatly in material and fabrication costs.

Almost any shape can be produced by Alcoa — hollow, semi-hollow, solid. While cross sections must remain constant throughout the length of the shape, extrusions permit thick sections where stresses are concentrated — thin sections in areas of minor loading. In both metal cost and shop time, extrusions often can save substantially over roll forming or building up an equivalent section.

To help you visualize the almost limitless possibilities of aluminum extrusions, and to suggest ways you can adapt your designs to them, Alcoa has prepared a special booklet that's yours for the asking. Write for "Alcoa Aluminum Extruded Shapes."

Booklet offers basic design help...

- a discussion of design and production advantages of aluminum extrusions.
- examples of aluminum extrusions that have increased strength and stiffness because of efficient metal distribution.
- examples of designs that have been simplified by the use of a single extruded shape to replace expensive built-up assemblies, castings or machined sections.
- illustrations of the way several extruded shapes can be combined to simplify assembly and reduce costs.
- suggestions on modifying designs to utilize standard shapes and shapes for which dies are available.

ALCOA

ALUMINUM COMPANY OF AMERICA • 1807F GULF BLDG., PITTSBURGH, PA.

New automatic has extra strength . . . extra precision . . . with help of TIMKEN® bearings

DESIGNED for heavy-duty performance, this new Acme-Gridley Single Spindle Automatic Bar Machine maintains its high precision even at the fastest feeds and high spindle speeds at which carbide tools can be safely operated. And one good reason for this strength and accuracy is the Timken® tapered roller bearings on the spindle and in the gear box.

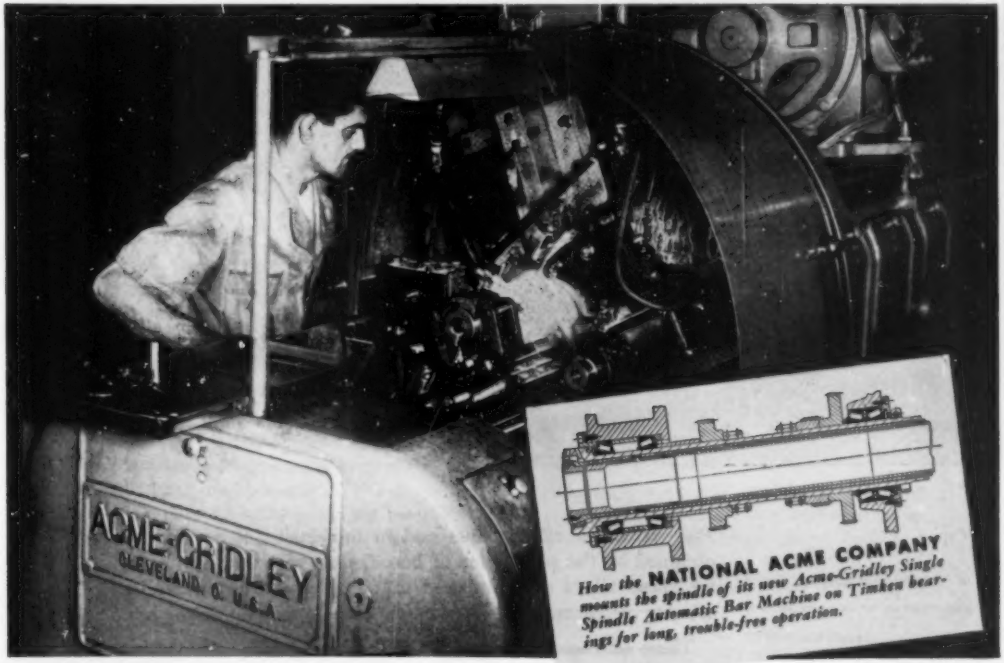
Timken bearings hold the spindle in rigid alignment, yet free to rotate easily. Deflection and end-movement are minimized. Spindle chatter is prevented. And Timken bearings on the first and second intermediate shafts keep gears meshing smoothly, reduce wear on moving parts.

Because of tapered construction, Timken bearings take both radial and thrust loads in any combination. Line contact between rollers and races provides extra load-carrying capacity.

The true rolling motion and incredibly smooth surface finish of Timken bearings practically eliminate friction. Case-carburized, the rollers and races of Timken bearings have a hard, wear-resisting surface and a tough, shock-resisting core. Since Timken bearings are 1) engineered for the job 2) precision manufactured and 3) made of special analysis Timken fine alloy steels, they normally last the life of the machine.

No other bearing can give you *all* the advantages you get with Timken tapered roller bearings. Make sure you have them in every machine tool you build or buy. Look for the trademark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



How the **NATIONAL ACME COMPANY** *mounts the spindle of its new Acme-Gridley Single Spindle Automatic Bar Machine on Timken bearings for long, trouble-free operation.*

WE MAKE OUR OWN STEEL

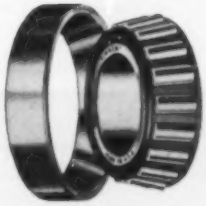
The special grade alloy steel which gives Timken bearings their strength and resistance to wear, is made in our own steel mills.

The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TRADE MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↓ AND THRUST →○← LOADS OR ANY COMBINATION →○←

Plus values in effectiveness and in uniformity of results are obtained by the production of boron steels with Grainal alloys, for these alloys are composed of boron *plus* other carefully selected elements.

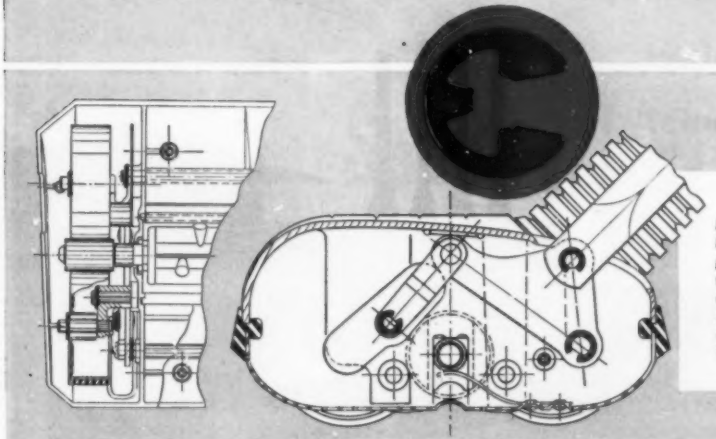
These additional elements . . . by combining with excess nitrogen and oxygen . . . enable the boron to function most effectively and thus consistently secure maximum benefits.

VANADIUM CORPORATION OF AMERICA

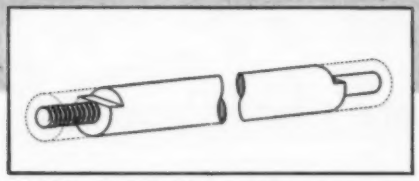
420 LEXINGTON AVENUE, NEW YORK 17, N. Y. • DETROIT • CHICAGO • CLEVELAND • PITTSBURGH

MAKERS OF ALLOYS
VANCORAM
CHEMICALS AND METALS

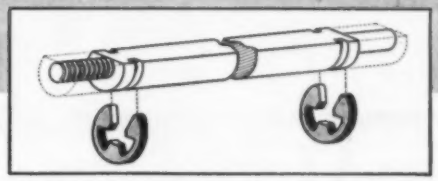
12 TRUARC RINGS SAVE 25% MATERIAL ...50% LABOR COSTS...50% ASSEMBLY TIME



With Waldes Truarc Retaining Rings, assembly in hard-to-reach places is easier, since there are no washers and bulky lock nuts. Smaller shafts can be used. Unit is smaller, lighter, more efficient!



CONVENTIONAL WAY: 2 round rods were required, milled down to D-shape. 4 threading operations to accommodate lock nuts.



TRUARC WAY: Truarc Rings allowed Lewyt Corporation to use 2 stock D-shape rods. No milling . . . no threading—just 2 grooves!

Using 12 Waldes Truarc E Retaining Rings in their new "101" Vacuum Cleaner nozzle brought the Lewyt Corporation, Brooklyn, N. Y. tremendous material and labor savings . . . eliminated 2 milling and 12 threading operations . . . made possible the use of stock extruded D-shaped rods . . . simplified maintenance. And with Waldes Truarc Rings unit is 15% lighter . . . 10% smaller overall!

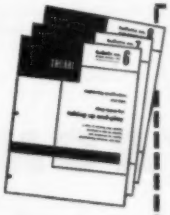
Redesign with Truarc Rings and you too will cut costs. Wherever you use machined shoulders, bolts, snap rings, cotter pins, there's a Waldes Truarc Retaining Ring designed to do a better job of holding parts together.

Waldes Truarc Rings are precision-engineered . . . quick and easy to assemble and disassemble. Always circular to give a never-failing grip. They can be used over and over again.

Find out what Truarc Rings can do for you. Send your blueprints to Waldes Truarc engineers for individual attention, without obligation.

Waldes Truarc Retaining Rings are available for immediate delivery from stock, from leading ball bearing distributors throughout the country

SEND FOR NEW BULLETINS



WALDES TRUARC

REG. U. S. PAT. OFF.

RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

WALDES TRUARC RETAINING RINGS ARE PROTECTED BY THE FOLLOWING PATENT NUMBERS: U. S. PAT. 2,382,948; 2,420,021; 2,411,761; 2,467,803; 2,467,802; 2,491,306 AND OTHER PATS. PEND.

Waldes Kohinoor, Inc., 47-16 Austel Place PN 063
Long Island City 1, N. Y.

Please send Bulletins 6, 7 and 8—giving engineering specifications for all types of Waldes Truarc Rings.

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone_____ State_____

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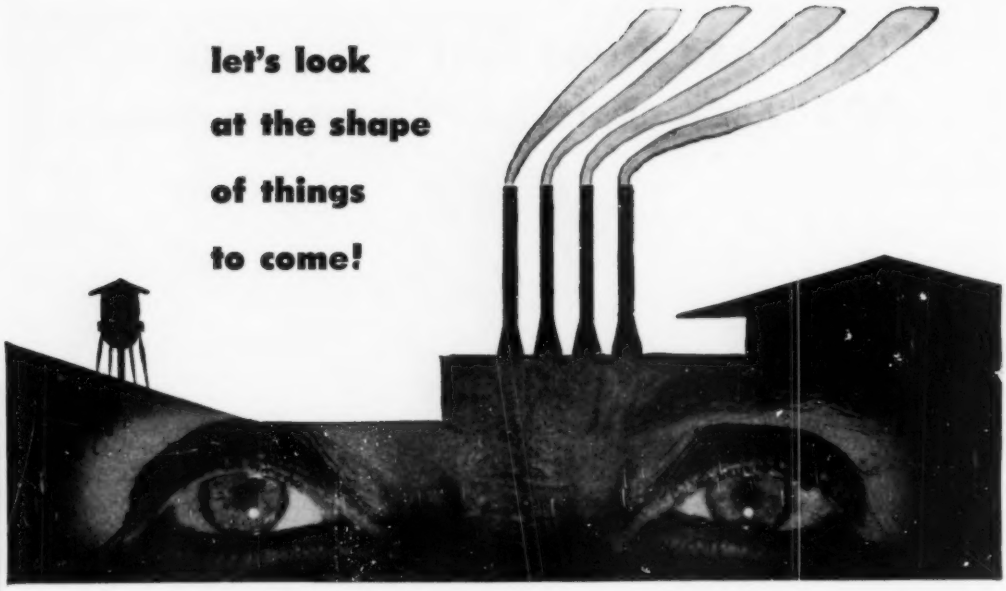
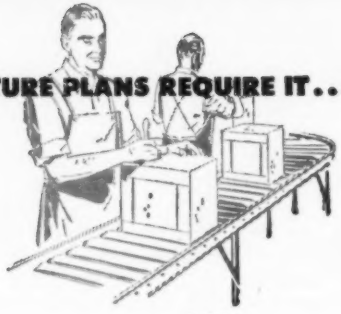
let's look at the shape of things to come!





...IF FUTURE PLANS REQUIRE IT...here's how you can cut costs with fewer assembly operations

Look to plastics . . . and particularly polystyrene . . . for a speedier production cycle.

Through advances in polystyrene research, in molding techniques and machinery, you now can make *larger area moldings* . . . many with complicated and intricate designs *in one operation*. These new moldings may help you to cut many assembly steps with the result . . . more units per day at lower cost. Also . . . polystyrene has built-in color . . . color that won't chip, peel or rust. This feature eliminates many finishing operations.

Dow, as a leader in the plastics industry, offers you a complete line of *quality controlled* Styron (Dow polystyrene) plastics, plus the expert assistance of Dow's Plastics Technical Service. When you look at the shape of things to come in '51, be sure to include Styron in your planning for future civilian or defense products. Write Dow today.

Plastics Division—Dept. PL-70

THE DOW CHEMICAL COMPANY
MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington
Atlanta • Cleveland • Detroit • Chicago • St. Louis
Houston • Los Angeles • San Francisco • Seattle
Dow Chemical of Canada, Limited, Toronto, Canada

STYRON

a quality plastic for a quality job!

DOW plastics

HIT BY LACK OF TIME AND PARTS?

OILITE Finished Machine Parts give you these important advantages:

- Quick delivery
- No tooling program
- Low price
- Release of skilled manpower
- Conservation of strategic materials

ALTERNATE MATERIAL
Oilite gives you a dependable alternate for bronze, brass, aluminum, cast iron, steel, and plastics.

MACHINING ELIMINATED
Oilite processes help you eliminate as many as twenty-four machining operations.

SIMPLE TOOLING
Oilite products require little tooling; saving you floor space, jigs and fixtures, skilled manpower, and time.

UNDUPLICATED EXPERIENCE
Oilite engineers pioneered iron powder metallurgy; their experience of more than twenty years, and Oilite's broad facilities are at your disposal.

OILITE FERROUS-BASE BEARINGS
Heavy duty, oil-cushion, self-lubricating.
Excellent for replacing your nonferrous units of solid material.

Oilite representatives and field engineers are located throughout the U. S. and Canada. You are invited to contact the field engineer in your district or write the home office.

AMPLEX MANUFACTURING COMPANY
Subsidiary of Chrysler Corporation
DETROIT 31, MICHIGAN

Besides Field Engineers, Supply Depots, too, are maintained in Principal U. S. and Canadian Cities.

A Note to Executives

Some facts about Oilite Products

Essentially, Oilite metal powder products constitute a new series of metals—each formulated to do a specific job. When used as replacements for tin, aluminum, copper, and other strategic materials, they often become permanent replacements.

For example, on any unit where motion occurs, Oilite provides the otherwise unobtainable feature of self-lubrication.

As with any other new material, habitual specifications should often be reviewed when considering Oilite finished machine parts. To illustrate, designers using cold rolled steel, may automatically apply the strength specifications of that material. The engineer, however, knows that strength as low as 40% of steel is satisfactory.

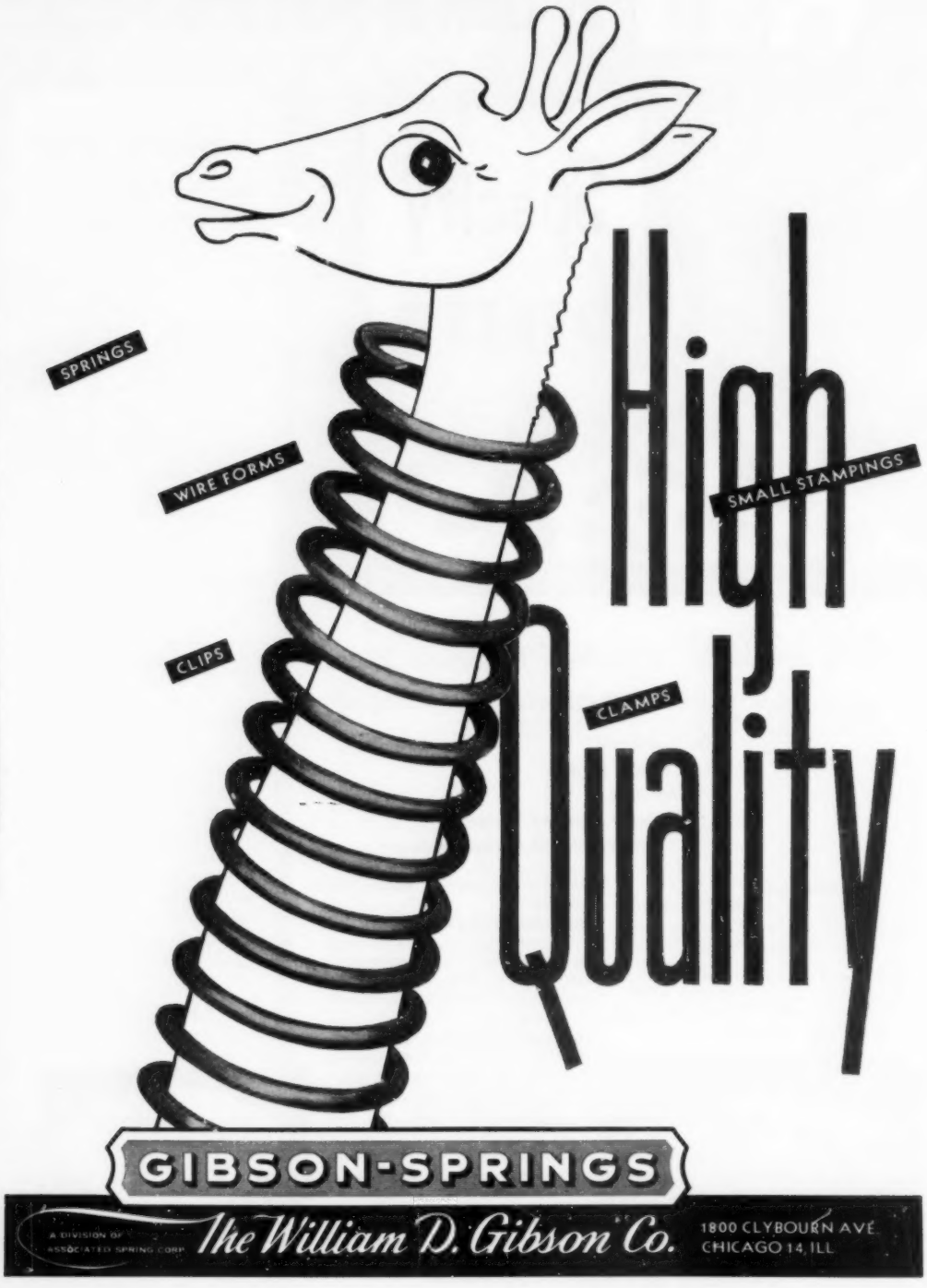
Another advantage of Oilite is its broad range of physical properties. Thus, when high stresses exist, Oilite engineers specify the correct material necessary to meet the requirements.

When production, including mass quantities, must be reached in record time, Oilite bearings and finished machine parts may provide you with an excellent reservoir.

President

OILITE
PRODUCTS

OILITE PRODUCTS:
Heavy duty, oil-cushioned, self-lubricating bearings and finished machine parts in ferrous and nonferrous metals and alloys. Permanent filters. Friction units. Self-lubricating cored and bar stock.


SPRINGS
WIRE FORMS
CLIPS
CLAMPS
SMALL STAMPINGS
High Quality
GIBSON-SPRINGS
A DIVISION OF ASSOCIATED SPRING CORP.
The William D. Gibson Co.
1800 CLYBOURN AVE.
CHICAGO 14, ILL.

Adhesives eliminate rivets in attaching automobile clutch facings. This eliminates slow and costly riveting operations and reduces the danger of damage from rivets. This 3M adhesive application decreased the number of rejects.

Strippable Coatings protect metal from scratches, abrasions and mars during the manufacture of many products. One user reports savings of more than $100 a day in terms of speeded production and elimination of rejects.

ADHESIVES COATINGS SEALERS

3M COMPANY

Sealers for Integral Fuel Tanks serve both military and commercial aircraft. This application of a 3M adhesive makes possible the sealing of wing compartments to serve as fuel tanks, rather than using separate fuel cells which are heavier and more costly.

IT TAKES TEAMWORK TO MAKE THINGS STICK!

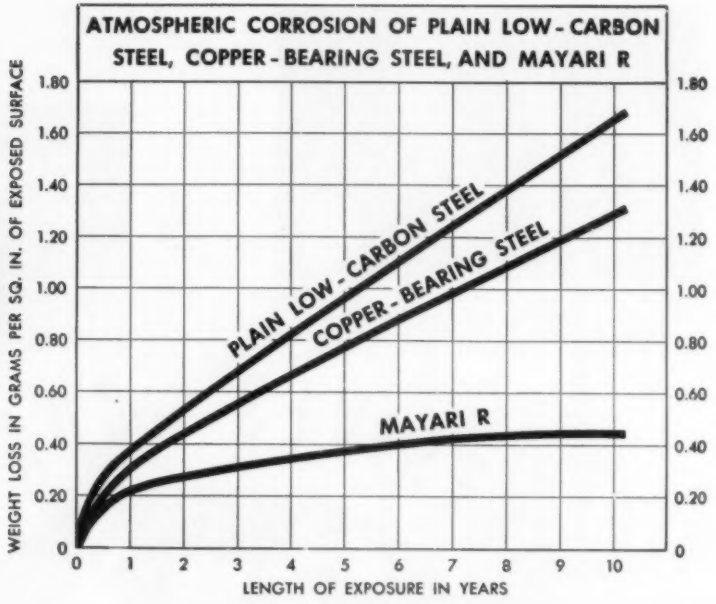
The problem of making one material stick to another requires the same type of research and engineering necessary in many other technical problems.

That's why 3M offers you not only top-product quality but *service* . . . service based on the teamwork of our skilled research technicians and laboratory-trained field engineers. These specialists are always available to consult with you on problems of design and production. From field reports, research technicians can draw from over 1,000 basic formulas to select the right adhesive for your requirements.

With 20 offices conveniently located to help you, 3M service is as close as your telephone; or, write directly to Dept. 46 in Detroit.

ADHESIVES AND COATINGS DIVISION • MINNESOTA MINING AND MANUFACTURING COMPANY
411 PIQUETTE AVE., DETROIT 2, MICH.
GENERAL OFFICE: ST. PAUL 6, MINN.
EXPORT AND CANADIAN SALES: 270 PARK AVE., NEW YORK 17, N. Y.

10 YEAR TEST



shows how MAYARI R resists atmospheric corrosion

The curves plotted on this chart show the weight losses, due to atmospheric corrosion, of plain low-carbon steel, copper-bearing steel, and Mayari R. These three types of steel were exposed for a 10-year period, under exactly the same conditions, in a highly corrosive industrial atmosphere.

Relatively little difference was found in the weight losses of the three steels in the initial period. However, as the test continued, the difference in the rates of corrosion changed appreciably. The Mayari R curve became almost horizontal, indicating that corrosion had practically stopped. The other two curves continued to rise sharply, showing that corrosion continued unabated in both the carbon steel and copper-bearing steel.

It is important to note that after 10 years of exposure, Mayari R had lost no more weight than copper-bearing lost in 2 years, and no more than carbon steel lost in 1½ years.

The superior resistance to atmospheric corrosion shown by Mayari R is mainly due to the relatively thick and tightly adherent layer of rust that forms on the surface of this steel to protect it from further loss of weight.

This superior corrosion-resistance is one of the important reasons why Mayari R is now widely used in railway cars, mine cars, bridges, industrial structures, coal silos, smoke stacks and countless other applications where long service life and low-cost maintenance are essential.

For more information on this versatile grade of steel, call or write any of our sales offices.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

★ BETHLEHEM STEEL ★

Mayari R *makes it lighter... stronger... longer lasting*

No shutdown, no slowdown and no bearings missed with Farval lubrication

WEBER bag machines produce paper bags at speeds up to 500 per minute. Machines are run continuously at high speeds up to 24 hours a day, and in all climates all over the world.

Good lubrication—vital to trouble-free operation—is provided by Farval Centralized Lubrication, which is offered as optional equipment on every machine.

According to the machine manufacturer:

"Centralized lubrication with Farval is a distinct aid to positive lubrication of hard-to-get-at places which previously required the machine to be shut down to reach the hidden bearings that were frequently missed entirely, either intentionally or due to an oversight.

"The closed bearings now used with the Farval system also practically eliminate any possible abrasive effects where undesirable conditions are encountered. Maintenance time has been cut to a minimum, since the entire machine can be lubricated while in operation. Bearing life has been increased tremendously. Oil and grease drippings have been eliminated since lubrication is clean and efficient with no waste lubricant to soil machine or paper bags."

Farval is the original (patented) Dualine system of centralized lubrication that has proven itself through years of service. The Farval valve has only two moving parts—is simple, sure and foolproof, without springs, ball-checks or pinhole ports to cause trouble. Through its full hydraulic operation, Farval unfailingly delivers grease or oil to each bearing—as much as you want, exactly measured—as often as desired. Indicators at every bearing show that each valve has functioned.

Write for Bulletin 25 for full details. The Farval Corporation, 3279 East 80th St., Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

FARVAL—*Studies in Centralized Lubrication*
No. 115

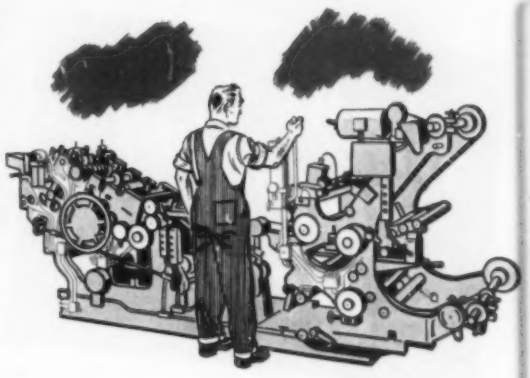
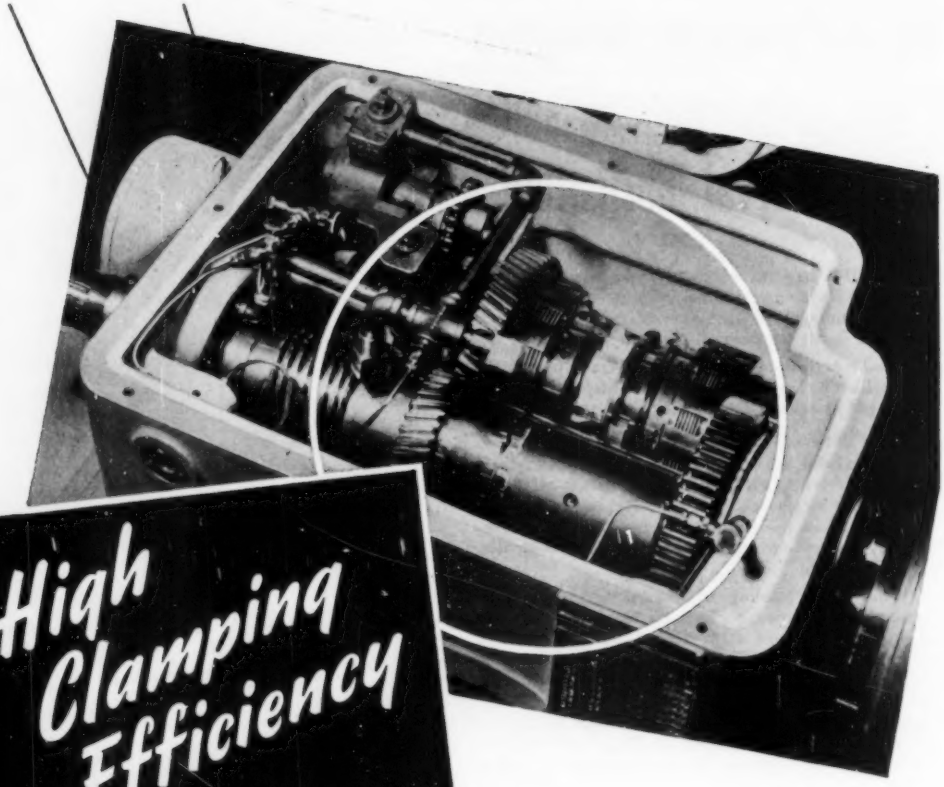


Illustration courtesy of H. G. Weber & Co., Inc., Kiel, Wis.



High Clamping Efficiency

Automatic speed-change Twin Disc Multiple Clutch in the head of a Monarch Tool Company Model Z electrically controlled step shaft contour or form turning automatic lathe.

● Clamping efficiency with comparatively low pressure on the clutch lever, high torque capacity, ease of operation and single point adjustment . . . combine to make Twin Disc Machine Tool Clutches "wear like a bearing and perform like the best friction clutch."

Designed to operate in limited space, the clamping efficiency of Twin Disc MTU and MTS Clutches permits the clutch length to be kept to a minimum. Unaffected by centrifugal action, high speeds of rotation are possible. All parts are machined to close tolerances. Operating parts are heat treated for maximum strength, longer wear-life.

For complete information on Twin Disc Model MTU and MTS Clutches, oil or dry type, single or duplex, write for Bulletin No. 134-A. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

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The Durability of BM-13080

BM-13080 is an improved impact BAKELITE Phenolic Molding Material that retains its mechanical strengths under long periods of immersion, exposure to high humidities, elevated temperatures, and mild alkali and acid solutions.

Millions upon millions of housewives, by putting their washing machines to hard service over a period of years, have provided the finest test imaginable to prove the durability of BAKELITE Phenolic BM-13080, employed for the agitators in these machines.

Such outstanding service has led naturally to other important applications. Today BM-13080 is employed for such parts as pump rotors, valves, baffle plates, gasoline pump components, soap injectors, water filters, and a great variety of equipment that calls for retention of impact strength, plus resistance to heat, moisture, and chemicals.

BM-13080 is readily molded into rich, black, smooth-surfaced products. Here are typical properties obtained by testing standard test specimens in accordance with ASTM procedures:

Molded Specific Gravity (D392-38)	**1.36-1.39**
Heat Distortion Temp. (D648-45T)	**290° F. min.**
Water Absorption (D570-42) Per Cent Gain in Weight	**0.7 max.**
Izod Impact Strength (D256-47T) Ft. lb./Inch of Notch	**0.46 min.**
Compressive Strength (D695-44T) psi	**25,000 min.**
Tensile Strength (D651-48) (⅛"), psi	**6,500 min.**
Flexural Strength (D790-45T), psi	**9,000 min.**
Modulus of Elasticity in Flexure (D790-45T), psi	**9×10^5 min.**

You, too, may have need for a superior phenolic plastic to meet exacting specifications for defense or essential civilian uses. If so, it will pay you to investigate BAKELITE Phenolic BM-13080.

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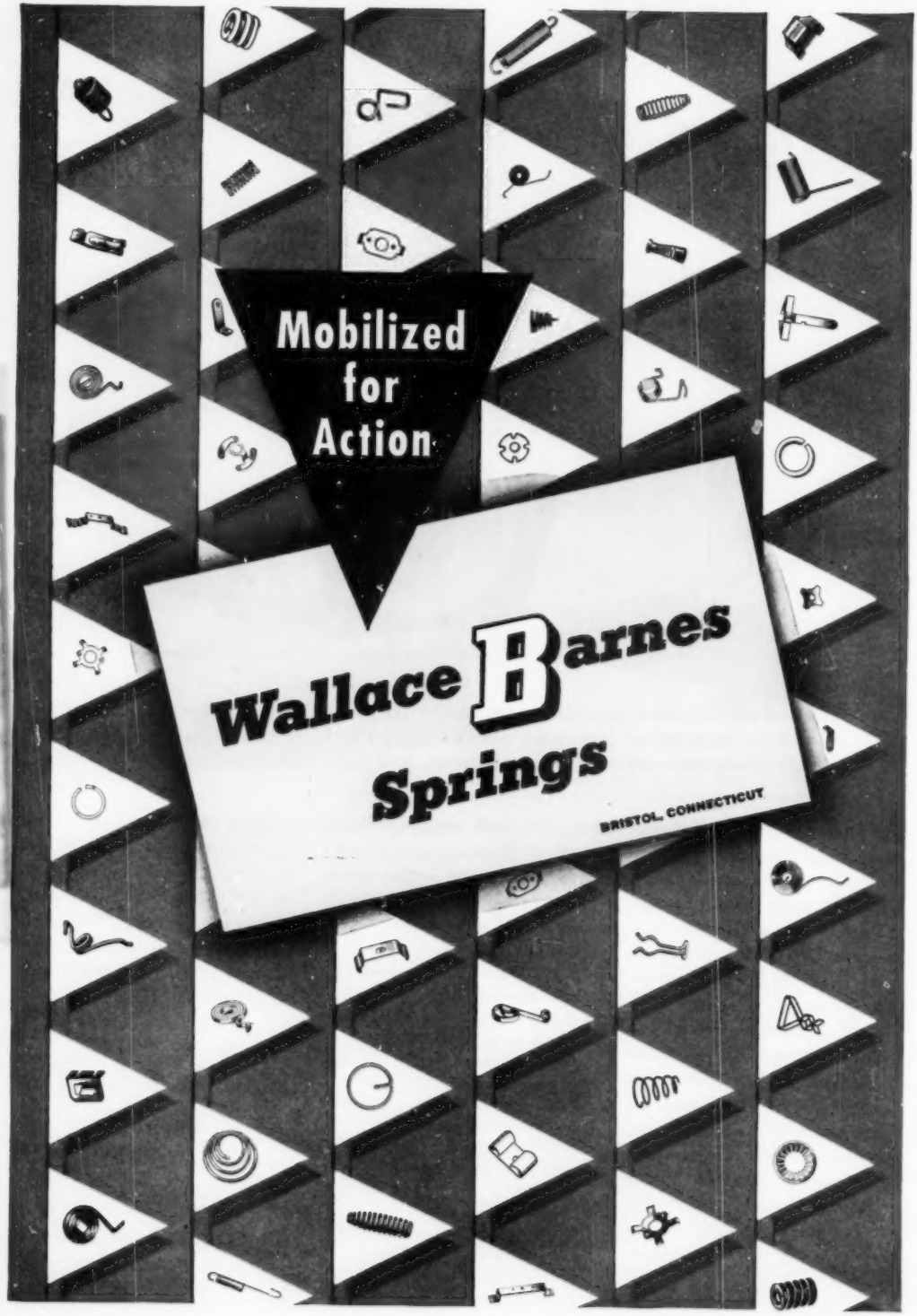
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Where the going is really rough, spring-loaded leather grease seals provide rugged dependability

Heavy equipment quite naturally requires ruggedly constructed components throughout. It is not surprising that the grease seals employed in the "Caterpillar" DW-20 Tractor (Fig. 1) are of the most rugged construction and

Figure 1
"Caterpillar" DW-20 Tractor.

are capable of dependable performance under the most gruelling operation.

At the rear bearing position of the clutch assembly (Fig. 3) two National 50,000 series spring-loaded leather grease seals are employed. The seal (A) at the inside position faces the ball bearing and its main function is to prevent grease from entering the clutch. The seal (B), however, is faced away from the bearing and effects a seal on the coupling (not shown) which joins to the splined drive shaft. Facing this rear seal outward permits flush lubrication of this bearing as grease is forced in through the fitting at the top. At the same time this outward-facing seal provides protection against extraneous matter which is encountered under the usual operating conditions of equipment of this kind.

A distinct advantage of the spring-loaded leather oil seal is its rugged construction. Such seals, particularly the 50,000 series National Oil Seal (Fig. 2), are of a heavy construction. This provides a margin of safety against inexpert replacement techniques in the field.

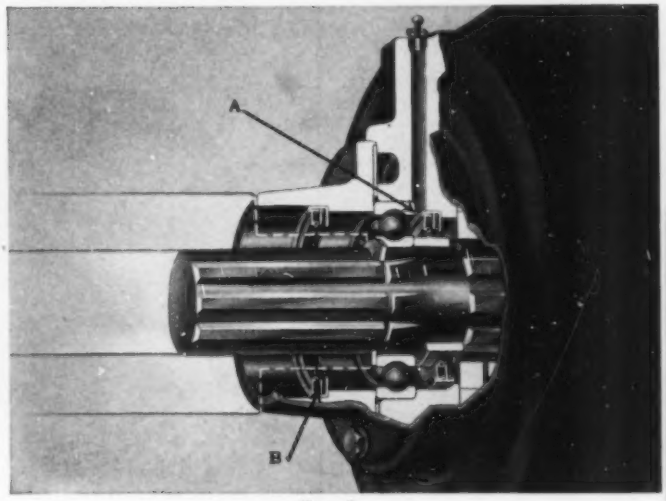

Figure 3
Cut-away drawing of Rear Clutch Bearing.

Figure 2
National 50,000 series Leather Grease Seal.

And, furthermore, because the leather sealing members are able to retain lubricant within themselves, these seals can operate under dry conditions for some time . . . a safety margin against neglect of lubrication.

Single-wipe spring-loaded leather seals are generally available in almost any standard bore or shaft size. For complete information, write direct to factory or get in touch with the nearest National Oil Seal engineer.

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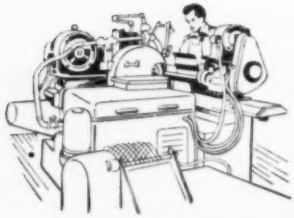

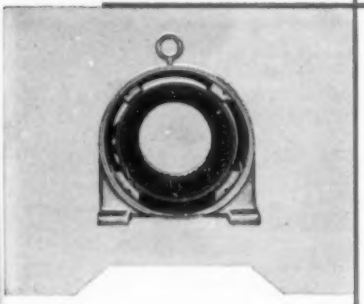

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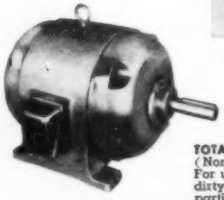

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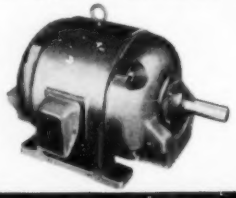
For use in exceptionally dirty atmospheres, particularly when metallic dust is present.



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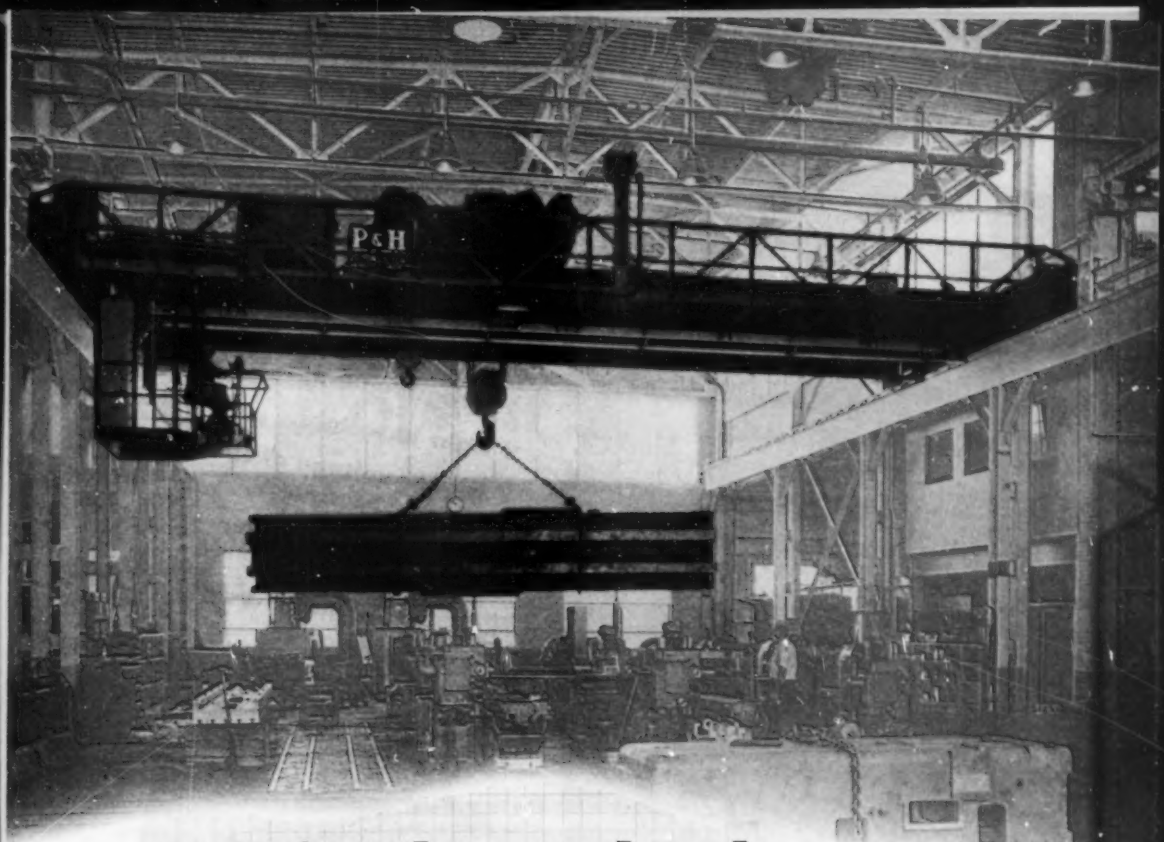

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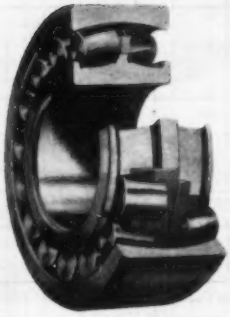
with Torrington Spherical Roller Bearings



Harnischfeger Corporation uses Torrington Spherical Roller Bearings for the trolley drive of P & H overhead cranes to assure smooth and dependable operation.

Spherical Roller Bearings automatically compensate for shaft deflection and frame distortion so that binding stresses are avoided. These precision bearings require a minimum of maintenance attention.

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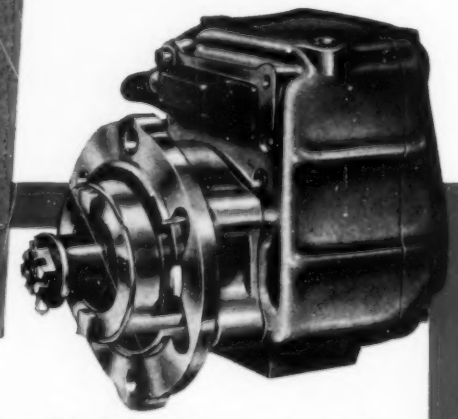

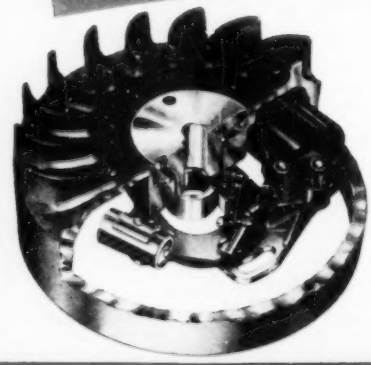

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We Mobilize for Freedom

WHY Controls are Necessary

One of the encouraging characteristics of the American people is their dislike for government controls. This augurs well for the future of their economic and political freedom.

But for the next few years we must not only tolerate but also help to make effective a whole battery of emergency government controls over our economic life. If we fail to do this now the future of that freedom we cherish will be imperilled. It is the purpose of this editorial—the third in a special series—to explain in simple terms why this is so.

After our military victory in World War II, we rushed through a demobilization which cut our military strength to about one-tenth of its wartime peak. Our allies did much the same thing. But the Russians maintained much of their wartime military strength and built up that of their satellites. With prodigious speed we switched from military to civilian production and went on to enjoy a rousing postwar boom—the greatest in our history.

This boom was in vigorous progress when, on June 25 last year, the Russian-sponsored North Korean army attacked South Korea. Our industrial production was rolling along at almost twice its prewar level. We had labor shortages in many key industrial areas. Under the impact of heavy buying all along the line, prices were climbing.

When the North Koreans smashed into South Korea they smashed into our national consciousness this fact: if we want a fair chance to save our national freedom from destruction by Communist aggression, we must race to restore some of the military power we had so speedily written off after World War II. And we must do it with our resources already very fully occupied with a boom in civilian business.

Program Small Compared to World War II

Compared with our military effort in World War II, the mobilization on which we are now embarked is small. At its peak, under present schedules, it will absorb no more than one-fifth of the total national production. During World War II we reached a point when nearly half of our total production went for war-making.

Moreover, our economy now is much bigger and stronger than it was in World War II. During the last decade there has been an increase of about 15 percent in our labor force. Our workers have had the training advantage of steady employment. The capacity of our industrial establishment is two-thirds again as great as it was ten years ago. Since the war no less than $70 billion has been spent to expand and modernize it.

Given time, the industrial giant we have created could pick up in its stride the added load of production for defense that now is con-

templated. But speed is of the very essence. There is little dissent from the proposition that if we are to stand off Russian aggression successfully we have, at the outside, two years in which to get ready.

Controls Needed to Prevent Chaos

These two facts – (1) the necessity for speed in our rearmament program and (2) an economy already stretched taut by a record civilian boom—create the general necessity for government controls. If we simply pile the billions of added defense expenditures authorized since last June on top of the civilian boom, and let it go at that, two destructive developments would follow. There would be a scramble for scarce materials, notably metals, which would create chaos in those markets. And prices would go through the roof.

Our situation during this mobilization is radically different from what it was when we rushed to get ready for World War II. Then we started with an economy that was coming out of a long depression. There was plenty of slack. Even in mid-1941 we still had over 6 million unemployed. Thus it was possible for us to expand war production greatly and also increase civilian living standards before the limits of our productive capacity made extensive controls necessary. But as we begin this new mobilization we find our economy already operating virtually at capacity. This fact is of key importance in understanding why this relatively small defense program so quickly requires the imposition of controls.

The selection and administration of controls thus far has been badly bungled. The threat of price controls, for example, was broadcast so vigorously and for so long that our people were virtually asked to raise prices and thereby do much to defeat the controls. Adequate taxation directed so as to attack inflation at the source and thus give direct price control a chance to operate has not yet been provided.

Indeed, we could readily assemble a long and devastating catalog of the deficiencies of the government's control program. But that would not dispose of the necessity for controls – by priority, by allocation, and, as a stop-gap, by direct prescription of selling prices – if we are to carry out our mobilization successfully. That is the only means by which a clear right of way for defense production can be cut through the highways of trade and commerce now jammed with civilian boom business.

Hope In The Wilson Plan

Since he became Director of Mobilization, Charles E. Wilson has added a new element of order and hopefulness to the mobilization program. He has laid out a plan which, if we are spared all-out war, would do three things by 1953. First, it would produce the weapons needed by our army and our allies to meet an immediate threat. Second, it would create the capacity that would enable us to move at high speed into weapons production for all-out war – if necessary. Third, it would create the additional production capacity that would restore by that date our ability to resume the climb of the American civilian standard of living.

In technical and industrial terms the Wilson Plan seems to be feasible. If it is successfully carried out, we should be able to begin getting rid of controls rapidly by 1953. But to carry out the program successfully, it must now have vigorous support from everyone. That does not mean mere agreement that it is a good plan. It means that we must conform to the controls that are necessary to make the plan work. In developing this support, the business community is in position to exercise crucially important leadership.

As has often happened in our national history, we are confronted by a paradox. We must accept emergency controls for the time being to insure survival of the freedom that they infringe. But, as we do this, we may find some comfort in the reflection that while controls from Washington are hateful, controls from Moscow would be infinitely worse.

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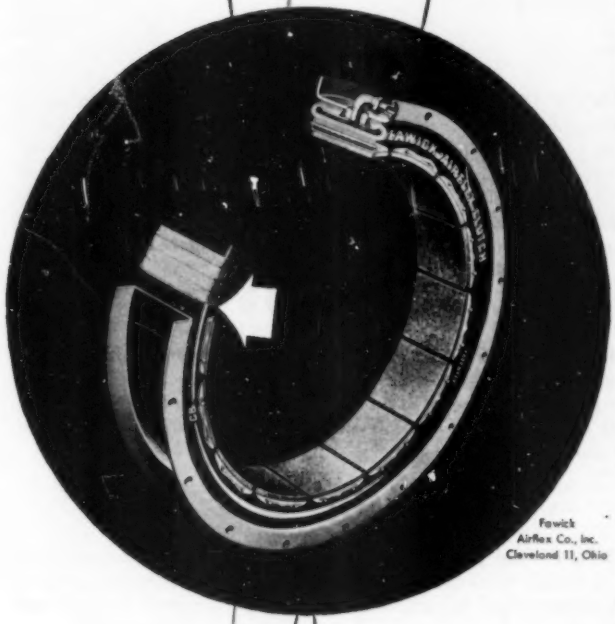
These properties of neoprene make a better PNEUMATIC CLUTCH



Fawick Airflex Co., Inc. Cleveland 11, Ohio

Basic element in this clutch is its actuating tube—made of neoprene reinforced with plies of rayon fabric. The tube is firmly bonded to the clutch rim, which is bolted to the driving unit. When air under pressure enters the tube, it expands and forces the friction shoes against a drum on the driven unit, and the clutch is engaged. These clutches are used extensively in all types of industrial applications, and in marine installations the change from full speed ahead to reverse can be made in *three seconds!*

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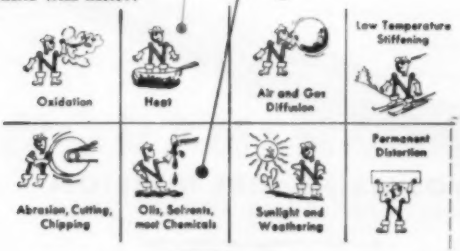

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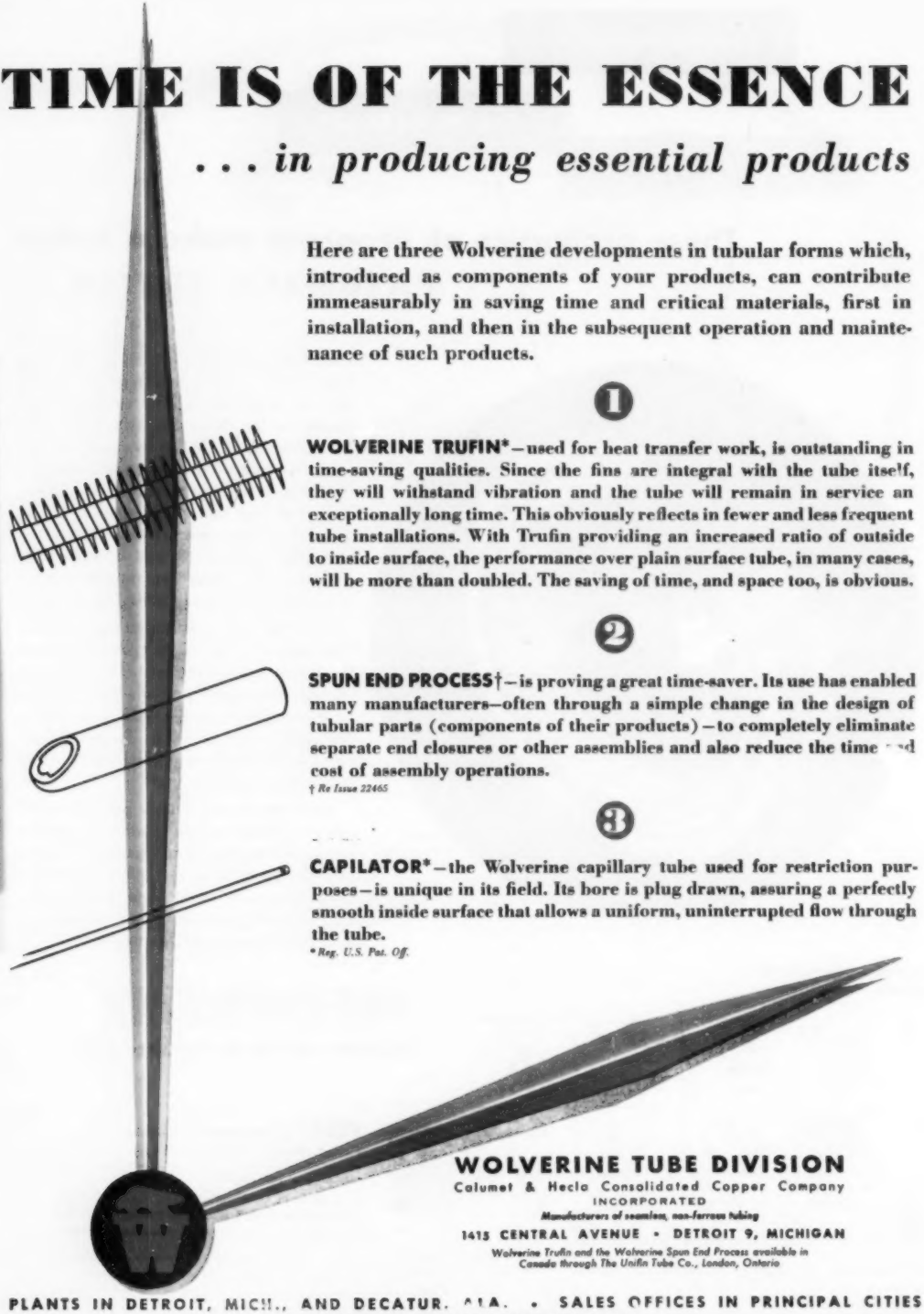
. . . in producing essential products

Here are three Wolverine developments in tubular forms which, introduced as components of your products, can contribute immeasurably in saving time and critical materials, first in installation, and then in the subsequent operation and maintenance of such products.



1

WOLVERINE TRUFIN*—used for heat transfer work, is outstanding in time-saving qualities. Since the fins are integral with the tube itself, they will withstand vibration and the tube will remain in service an exceptionally long time. This obviously reflects in fewer and less frequent tube installations. With Trufin providing an increased ratio of outside to inside surface, the performance over plain surface tube, in many cases, will be more than doubled. The saving of time, and space too, is obvious.

2

SPUN END PROCESS†—is proving a great time-saver. Its use has enabled many manufacturers—often through a simple change in the design of tubular parts (components of their products)—to completely eliminate separate end closures or other assemblies and also reduce the time and cost of assembly operations.

† *Re Issue 22465*

3

CAPILATOR*—the Wolverine capillary tube used for restriction purposes—is unique in its field. Its bore is plug drawn, assuring a perfectly smooth inside surface that allows a uniform, uninterrupted flow through the tube.

* *Reg. U.S. Pat. Off.*

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Here's a 26-word description of the V-belt sheave that is used more than any other.*

Two parts for easy handling—separately or together. Split hub and taper-mated rim make mounting easy. No realignment problem—clamped hub stays put while changing rims.

That's Worthington's QD—the original tapered cone-grip sheave that's preferred by men who have to install or change sheaves. The QD is *easy to get on, easy to get off, yet always tight on the shaft*—tighter than any other sheave on the market. Hubs for every bore—lower inventory cost.

For your machines, pick Worthington Multi-V-Drives with QD sheaves and Worthington-Goodyear EC Cord V-belts.

Worthington's complete line also includes FHP drives—QD Junior (quick-detachable) V-pulleys and many other styles.

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MV.1.8

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THIS EXPLODED VIEW of the revolutionary, new Sier-Bath Gear Coupling shows how Clipper Seals helped one enterprising manufacturer achieve simplicity and compactness in the design of his product.

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If you are looking for an oil seal that will help streamline your product, it will pay you to investigate Clipper Seal's many advantages. They are available in various lip designs to provide a choice of bearing surfaces, in sizes to fit shaft diameters from ⅜" up to 66" and for temperatures up to 450 F. Just write Johns-Manville, Box 290, New York 16, N. Y. Ask for brochure PK-46A.

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Johns-Manville CLIPPER SEALS

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COPPER ALLOY BULLETIN

"Bridgeport" BRASS CO. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL

Broken wheel being braze welded using low fuming bronze rod. Repaired impeller blades and cast iron housing are on the bench.

Braze Welding on the Increase for Repair and Maintenance

Braze welding showed its value as an essential maintenance tool in World War II. Consequently, it is expected to do even a bigger job in the period ahead when equipment shortages will become a major problem.

Broken machines and equipment cause serious stoppages in production while waiting for replacement castings and parts.

Urgent repairs can be made by braze welding in a matter of minutes or possibly hours depending upon the size of the job. If properly done, the bronze weld will be stronger than the parent metal.

Advantages of Braze Welding

Welders trained to repair parts with cast iron or steel welding rod will find many advantages in braze welding with bronze welding rod alloys. In general, it is cheaper than welding with steel especially when big, heavy parts are involved.

When welding cast iron or steel parts with steel or iron welding rod, in order to prevent stresses and warping, it may be necessary to preheat slowly the entire casting prior to welding and to allow the casting to cool slowly after the weld is made. However, in the case of braze welding, elaborate preheating and slow cooling of the casting are seldom required.

With braze welding, it is only necessary to heat the surface of the parent metal to a cherry-red heat. This is sufficient to produce the "tinning action" whereby the molten bronze firmly adheres to the red-hot surface of the parent metal.

Preparation

Certain precautions should be observed with braze welding. The broken section should be properly prepared and carefully cleaned.

Many welding operations require beveling on the edges of sheets and plates prior to joining, to enable the operator to obtain adequate penetration of the weld metal into the root of the weld. Where beveling is done by machining, little more cleaning is required. A wire brush may be used to remove any slight film of oil remaining after the machining process, and to eliminate any dirt picked up in handling. It will still be necessary to remove oxides, dirt, etc., near the edges of the joint as the machining cleans the metal only along the beveled edge itself.

Cleanliness Most Important

Oil or grease are especially harmful and should not be present even as a trace on the surface to be braze welded. Since broken metal parts of a machine are generally saturated with oil, it is a good practice to burn off the oil from the prepared surface by first playing a soft flame over that area. A neutral or slightly oxodizing flame should be used for braze welding. When grinding is done on cast iron, free carbon is smeared over the surface. It is desirable to use a highly oxidizing flame to preheat and remove this carbon. Special fluxes are also available for cast iron.

Any dirt, grease, oxides, etc., left on the work at the joint may easily be entrapped in the finished weld, preventing a strong bond between the parent metal and the bronze. Any foreign matter caught in the weld weakens the joint and increases the chances of early failure. When liquids or gases are concerned a weak bond may allow leakage along the joint between the base metal and the weld metal. (6599A)

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Says Ralph M. Watson, Assistant to the Vice-President — Engineering, Worthington Pump and Machinery Corporation, Harrison, N. J.

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T. S. FITCH
PRESIDENT

June 1, 1951

OPEN LETTER TO THE DISTRIBUTORS OF MICROROLD STAINLESS STEEL SHEETS

The current demand for Type 430 sheet is certainly a tribute to you distributors, and we want to take this opportunity to thank you for a job well done.

Because there is not sufficient nickel we asked our distributors, in July 1950, to explore the practicability of substituting Type 430 straight chrome stainless steel. While it is recognized that Type 430 is not a "cure-all", there are many applications where it does adequately provide the required corrosion resistance and other desirable characteristics.

We also wish to reassure you that we shall endeavor to allocate our production in an equitable manner.

Cordially yours,

TSF:HH

WASHINGTON STEEL CORPORATION

T. S. Fitch
President

PS.--You are aware of the fact that the government regulations require us to supply 40% of our production for Defense Uses; this obviously means that we cannot provide as much tonnage for non-defense purposes as we used to provide, nor as much as we would like to provide, at this particular time.

T. S. F.

Materials ~ AVAILABILITY AND TRENDS

CMP NO PANACEA

When CMP goes into effect July 1, it will make some materials more readily available for certain, specific purposes. But, in general, CMP has been over-sold as a solution to shortages.

Some will be disappointed early. If a product is listed on the official B list, the producer is allowed to file for a CMP allocation. How many B list applicants will be left in the cold is a question nobody can answer now. It depends, first, on a decision which NPA and CMP officials will not make. This decision is how the controlled materials--steel, copper and aluminum--are going to be divided up among the general programs, such as industrial equipment, tanks, ships, and farm equipment. The final allocations cannot be made, or their size determined, until Defense Production Administration has cut up the pie.

B list products which will get allocations are, in general, industrial machinery and equipment, components needed for defense, and those civilian-type products approved by the defense production authority.

Makers of A products will be invited to file for an allocation, either by the government claimant agency involved, or in the case of sub-contractors, by another company.

ALLOTMENTS

Allotments as granted by CMP will be "certified checks" for materials which will be much more easily honored than existing DO's. To this extent, CMP will make the acquisition of materials easier. But one industry's certified check is another industry's bare cupboard.

The amount of steel, copper and aluminum which will not be allocated is a matter of wide disagreement. CMP planners hope the DPA decisions will leave in the neighborhood of 70 percent of the steel free. But some steel industry experts predict the free area will be only about 25 percent of production. Guesses about copper and aluminum are similarly varied.

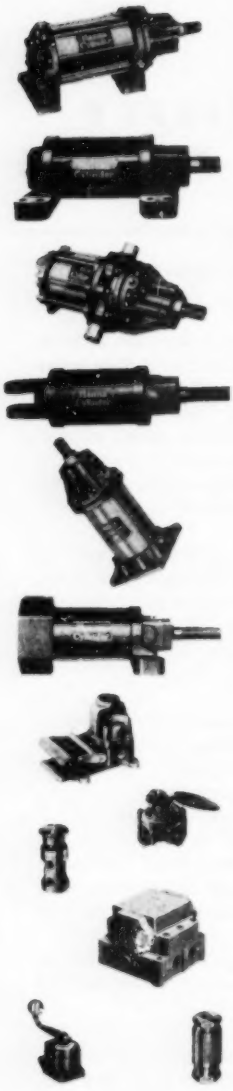
LOWER INVENTORIES

Officials expect CMP to end the practice of piling up large inventories. Nobody will be allowed more of the controlled materials than needed for the approved production schedule, quarter by quarter.

This will free some metal as CMP takes over, say in the first six months of its operation. Officials expect to find that some industries have much larger inventories of the controlled materials than they will be allowed to keep under the rules. Such industries will have to live off these inventories until they are worked down to the legal limits.

SPECIAL CONSIDERATIONS

Some particular types of products and materials for some particular purposes are going to get preferred status under CMP regardless of what DPA decides. Repair and replacement parts, for example. These will get allotments even if they are for civilian goods not on the B list. Laboratories and experimental projects will get a special order, allowing them to obtain controlled materials. And users of small amounts of the controlled materials need not even file for allocations. They will get their materials under another special order. Small users need not file if their total requirements on the following list does not exceed the specified amounts for the third quarter: carbon steel, 5 tons; alloy steel, 1/2 ton; copper and copper-base alloy, 500 lbs; aluminum, 500 lbs.



it took 50 *years*

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CYLINDERS . . . VALVES . . . RIVETERS

DO ratings will continue in use for all materials except steel, copper and aluminum and to some extent, even for these materials at least up to Oct. 1.

SCARCE MINOR METALS

In theory CMP will make it easier to get the scarce materials such as cobalt and nickel by carefully matching allocations with the number of end products approved. Makers of electronic products, for example, will get CMP allocations for defense production. In addition, makers of transmitting tubes will get enough nickel to supply the electronic industry's defense production needs.

A rise in demand for tungsten, with no increase in supply, is foreseen by NPA for July and August. Officials predict that the present adequate supply of fine wire will give way to a shortage when the forthcoming miniature and subminiature tube programs for radar and other uses get started. NPA is preparing an order to put tungsten under more complete allocation.

Restrictions on use of cadmium have been eased to some extent. Recent permissible uses include coatings on fasteners in the aircraft industry and for ferrous nuts, bolts, screws, washers, lock bolts, cotter pins and shear rivets. Its use is also allowed in automotive and aircraft fuel pumps.

NPA reduced the lead time on orders for most forms of molybdenum from 45 days to the 7th day of the month preceding the one in which delivery is requested. This change affects all forms of molybdenum except metal powder, wire, rod and sheet.

Speedier reporting of columbium-tantalum supplies was ordered with the idea of smoking out idle inventories. Holders of 10 lb or more during any calendar month are required to report inventory and consumption by the 7th day of the following month.

POLYSTYRENE OUTLOOK

As a result of the activities of the Injection Molders Committee on National Security, additional quantities of polystyrene will be made available. The four main accomplishments are: (1) Return to the plastics industry of styrene not used for the synthetic rubber program due to production rates lower than anticipated; (2) reduction of the styrene content of GR-S rubber; (3) lack of restricting governmental order concerning the plastics industry; (4) prompt action of the Rubber Reserve in getting the State Department to license imports of French and German benzene.

Future substantial relief is in the offering due to recent and proposed increased production facilities. Practically every material company now producing polystyrene is expanding its capacity. The SPI anticipates an increase by the third quarter of 1951 of 69 million pounds annually over the 660 million pounds produced in 1950.

SCRAP CONSERVATION

The scarcity of materials resulting from the nation's military program has stimulated conservation of scrap and material substitutions. A scrap conservation program at the Westinghouse Appliance Division plant resulted in recovery last year of 23,000 tons of steel and 815,000 pounds of non-ferrous metals.

Conservation of materials is a result of the use of material substitutions and changes in processing and design. Examples include the use of synthetic organic finishes instead of plating, copper brazing paste instead of solid copper wire, powder metal or plastics in place of cast or wrought metal, and silicone resin impregnated glass cloth instead of mica. Product improvement brought about by some of these changes will result in permanent application of the so-called substitutes.

Unique SPEED NUT Stars on Bendix Television

Product of Bendix Aviation Corporation

How multiple-function SPEED NUT made 40% savings in the assembly of TV transformer

Like the juggling stars on television, this new fastener does several jobs at one time . . . and provides several important cost-savings advantages.

Bendix Television engineers discovered this in their search for a better, simpler way of assembling high voltage transformers. Selected because it was engineered to do this specific job, this unusual Tinnerman fastener: *(1) replaced 4 parts, thereby reducing parts handling; (2) cut material costs 50%; (3) provided a 40% savings in cost of assembling transformer.*

It is through improvements and economies like this that Bendix Television, Baltimore, Md., is able to supply top quality "Front-Row" television receivers for thousands of American homes. You, too, can step up product quality and make production dollars go farther with SPEED NUTS. Your Tinnerman representative can show you how. Call him soon—and write for your edition of "Savings Stories"—actual case histories of leading manufacturers. TINNERMAN PRODUCTS, INC., Dept. 12, Box 6688, Cleveland 1, Ohio. In Canada: Dominion Fasteners Ltd., Hamilton. In Great Britain: Simmonds Aerocessories, Ltd., Treforest, Wales.

SPEED NUT holds transformer cores in spring tension grip, secures base by receiving 4 screws from below, and anchors top section with threaded shaft. One-piece fastener replaces 2 side fasteners, 1 bottom piece, 1 spring.
New Bendix Console Model
TINNERMAN
Speed Nuts

Why Engineering Must Be Recognized

GROSS SALES are always one of the highly important items on the balance sheets. Costs are another item. The former must be high; the latter must be low. Hence the precept: Spend the money to produce sales; be as economical as possible on costs; the difference is profit. From this over simplified statement of fact is drawn the sweeping conclusion: Spend on sales and sales promotion; engineering costs are a necessary evil and therefore cut them to the bone.

In too many companies the thoughtless application of this false premise has operated in reverse. Penuriousness in the budgeting of engineering costs results in losses that do not show on the books, and thereby are vicious indeed.

A large turnover in the personnel of the engineering department is in itself a relatively minor loss but in sum total it is far greater in dollars than any accounting system can possibly reveal. In addition to this, one must not lose sight of the fact that the greatest loss incurred by poor or mediocre engineering lies in the sales that might have been made had the product been designed better. It is impossible to even estimate the magnitude of such losses.

Unfortunately, when sales drop off the customary procedure is to put the pressure on selling and spend more money on it. More money is spent on sales promotion, often the sales department is increased. Ironically, the wiser and more fruitful course in many instances would be to put more money into the engineering of the product and thereby achieve an item that is able by its superiority and distinction to meet competition without the expenditure of excessive sales effort.

It is not often that the shortcomings of the design of the product are called to the attention of the manufacturer. Dissatisfied customers rarely complain unless it is to compel the manufacturer to make good on definite guarantees. It saves the customer time and annoyance to tolerate the design as it is. If practical to do so, the customer will have the product deficiency repaired at his own expense. But the next purchase of the same product is usually made elsewhere.

High class design cannot be produced in an unappreciated engineering department. The spirit of professionalism is lacking when commensurate rewards for creativeness are not forthcoming. A salesman in shabby clothes cannot bring in the orders; an engineer whose vision is shrivelled by his low economic status cannot be expected to produce at the highest levels.

It is not sufficient to recognize only the few keymen at the head of engineering. Recognition must go all down the line to the men at the drafting boards.

Just now there is a great scarcity of engineering design talent. Too few of the graduates choose engineering design for their life's work. The reputation of low pay in the lower brackets of engineering design has penetrated the college classrooms. As one vice president of engineering put it, the smart graduates who would undoubtedly make outstanding engineers are too smart to take a job in the engineering department. This is a gross exaggeration, but it is regrettably true that in too many concerns and too many engineering departments the salary scale is not attractive. This is a situation that industry must rectify and will be compelled to do so by the trends of the times. Companies that recognize engineering design on a professional basis will maintain their leadership. Those companies that fail to give such recognition will find themselves in other than the first ranks of their industry.

Engineering design is a profession and must be recognized as such.

G. F. Taderholt

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overlooks nothing that science or skill can contribute to make fine bearings better. New Departure ball bearings are now performing a great variety of services vital to the future of our country.

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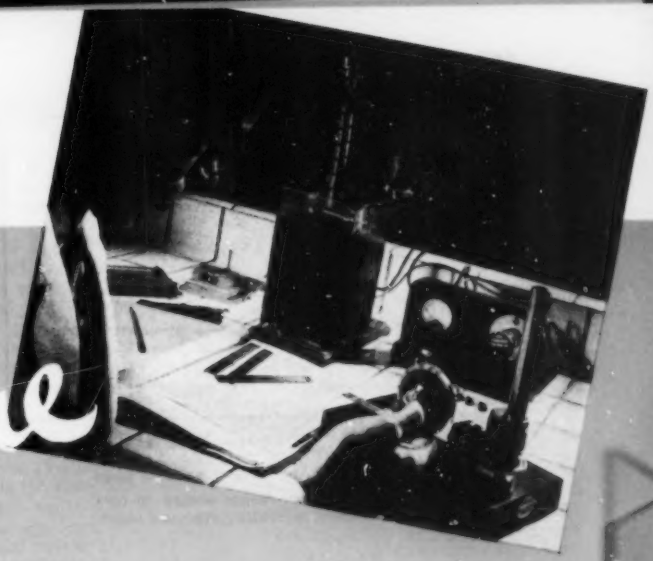
Fatigue



LOSS AND GAIN BY ELECTROPLATING

J. O. ALMEN
Research Laboratories Division, General Motors Corporation

• • • Data showing the reasons for the damage, and its extent, that is caused by electrodeposited metals when plated by the methods now in common use.

• • • Processes whereby advantages of rebuilding by electroplating can be retained without loss of fatigue strength.

• • • Suggested developments in electroplating processes, whereby electro-deposited coatings may possibly be made as effective as shot peening in increasing fatigue strength of plated machine parts.

THE ALWAYS TEMPTING IDEA of building up worn and undersized machine elements by electrodeposits is extremely hazardous when applied to highly stressed parts that are subject to repeated loads. The salvaging operation too often results in disastrous failure of the plated parts and severe damage to adjacent structures. When this rebuilding, as normally practiced, is applied to engines and other airplane parts there is, of course, the added danger of fatalities and injuries among passengers and operating personnel.

Numerous tests have shown that the fatigue strength of steel is greatly reduced when plated with hard metals such as copper, nickel, and chromium. Because of their better wear resistance and presumed structural strength, nickel and chromium, are usually selected for rebuilding operations.

Among the first to present quantitative values of the loss of fatigue strength as a result of electroplating was F. C. Lea (Ref. 1), whose fatigue test data are replotted in the S N diagram, Fig 1. Lea conducted fatigue tests by applying repeated push-pull loads to three groups of specimens made of: Commercial nickel; 14 percent carbon steel heat-treated to a tensile strength of 63,000 psi; and similar steel specimens plated with nickel. This S N diagram shows that the fatigue strength of the all nickel specimens is slightly greater than the steel specimens, and that the strength of the steel specimens is reduced by nearly one-half when a thin layer of nickel is electrodeposited on them.

Chromium plated rotating beam fatigue specimens of SAE 6130 steel were tested by H. K. Cummings, (Ref. 2) with the following results:

Steel Quenched and Tempered to 123,000 psi Tensile Strength	Endurance Limit, psi
Not plated	65,500
Plated 0.00015 in. thick	38,000
Plated 0.0045 in. thick	41,000

The results of tests reported by C. G. William and J. S. Brown (Ref. 3),

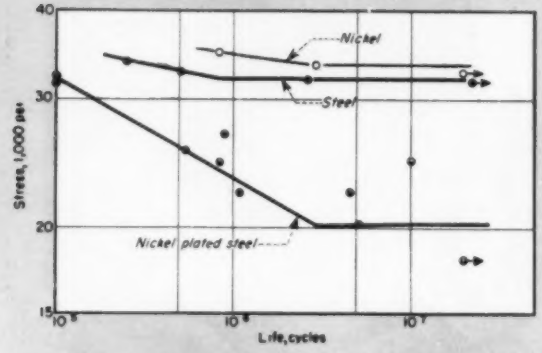


Fig. 1 — Loss of fatigue strength in steel when coated with electrodeposited nickel.

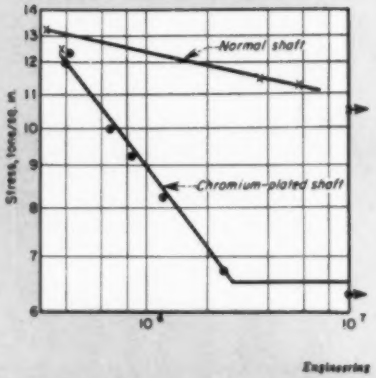


Fig. 2 — Fatigue strength of non-plated steel crankshafts and of chromium plated crankshafts.

demonstrate that the loss of fatigue strength of chromium plated machine elements is substantially the same as in laboratory specimens. The replotted S N chart, Fig. 2, shows that chromium plating reduced the endurance limit of steel crankshafts to nearly half of their unplated strength.

The converging characteristics of the fatigue curves for plated and unplated specimens, shown in the S N charts Figs. 1 and 2, also show that the strength of both kinds of specimens tend to become equal at the short life high stress levels. This observation agrees with static tests reported by F. C. Lea (Ref. 1) and by R. D. H. Blaklie and H. J. Davies (Ref. 4), which show that electroplating does not alter the static strength of steel.

The most plausible theories that have been advanced to explain the deleterious effect of electrodeposited metals on the fatigue strength of steel are:

1. The deposited metal is residually stressed in tension, from which it necessarily follows that the base metal is residually stressed in compression to maintain equilibrium conditions. When a crack forms in a strongly adhering deposit, the residual tensile stress is locally transferred to the base metal in the manner indicated by Fig. 3, thereby reducing the fatigue strength of the base metal. A further loss results because the crack constitutes a notch, which is a stress raiser just like a notch of similar depth and sharpness in the surface of the base metal.

2. The fatigue strength of the base metal is reduced as a result of brittleness caused by occluded hydrogen from the plating bath.

Measurements of Residual Stress

Observations indicating the presence of residual stresses in electrodeposited metals were reported as early as 1860, but E. J. Mills (Ref. 5) was the first (1877) to record attempted measurements of their magnitudes. He found that when thermometer bulbs were coated with certain electrodeposited metals the mercury rose in the stem, showing that the deposited metal was residually stressed in tension. He also noted that the deposited layer fractured when it became too thick. Through the changes in the height of the mercury column, Mills calculated that nickel could develop a pressure of 43,000 psi; iron 40,500 psi; and silver 149,000 psi.

Residual stresses in plated nickel were measured by G. G. Stoney (Ref. 6), in 1909, by a method capable of greater accuracy than Mills's measurement. Thin steel rules 102 mm long, 12 mm wide and 0.32 mm thick were varnished on one side and electroplated with nickel on the opposite side. In response to the residual tensile stress in the nickel layers, the plated rules bent concave to the extent of 3 to 4 mm on the plated side.

Measurements of the nickel thickness and the radius of curvature of the plated specimens provided data from which the residual stress was calculated. These calculated stresses, together with other pertinent data, are given in Table I. Note that Stoney succeeded in altering the magnitude

Table I—Residual Stress in Nickel Plated Thin Steel Rules

Spec. No.	Deposit Thickness, In.	Tensile Stress, psi	Bath Temp, F	Current, amp
1	0.0002	43,000	50 to 60	0.05 to 0.11
2	0.0018	40,500	50 to 60	0.05 to 0.11
3	0.0007	40,000	50 to 60	0.05 to 0.11
4	0.001	40,500	50 to 60	0.05 to 0.11
5	0.0003	40,000	50 to 60	0.05 to 0.11
6	0.0065	38,500	50 to 60	0.05 to 0.11
7	0.0005	17,500	50 to 60	0.22
8	0.0012	22,000	175 to 195	0.11

of the residual tensile stress by variations in temperature of the bath and in the plating current, as is shown in specimens number 7 and 8 by the reduced residual stress.

Blaklie and Davies measured the residual stresses in electrodeposited nickel, copper, zinc, and lead following the method used by Stoney except that the formula for calculating the stress was slightly modified. Table II gives the results of their measurements.

Other nickel plated specimens were prepared by Blaklie and Davies for which the conditions of plating were altered from direct current alone to alternating current superimposed upon direct current. Table III gives the measured residual stress in two specimens plated by this method.

Residual stress measurements shown in Tables II and III were followed by reverse bending fatigue tests with the following results:

(1) Uncoated steel specimens that otherwise were identical with the specimens of Table II, for which the endurance limit was found to be ±15,500 psi, with no loss of fatigue strength.

(2) Steel specimens plated with nickel as specimen 1 of Table II for which the endurance limit was found to be ±10,500 psi, with 28 percent loss of fatigue strength.

(3) Steel specimens nickel plated by AC-DC as the specimens in Table III, for which the endurance limit was ±14,200 psi, with 7 percent loss of fatigue strength.

Reversed bending fatigue tests of steel coated with the other electrodeposited metals recorded in Table II showed that: Copper plating resulted in a loss of approximately 14 percent, lead deposits resulted in a small fatigue loss; and zinc plating was found to give a small increase in strength. The loss of fatigue strength of the copper plated specimens presumably resulted from the stress raisers that became effective when cracks developed in the firmly bonded but relatively weak copper deposits.

The damage from nickel deposited in the usual manner was reduced from 28 to approximately 7.5 percent when the steel specimen was given a coat of electroplated lead before the nickel was applied. The ductile layer of lead presumably permitted relaxation of the residual tensile stress in the nickel layer, and any remaining stress was presumably prevented from reaching the underlying steel when cracks developed in the nickel coat.

Cracks in Chromium Plate

Extreme difficulty has been experienced in measuring the residual stresses in electrodeposited chromium. Within the range of normal current density and bath temperature, the tensile stresses are so great that the chromium deposits are almost invariably fractured during the plating operation.

Residual stresses in chromium deposits were measured by W. Hume-Rothery and M. R. J. Wyllie (Ref. 7) by means similar to those used by Stoney and by Blaklie and Davies. The residual stress that was developed in the normal plating range was found to reach 60,000 psi tension.

More recent measurements have been made by A. Brenner, P. Burkhead, and C. Jennings (Ref. 8) using an elaborate modification of the Stoney method. Helically wound steel ribbons were substituted for the flat strips previously used. Although large variations in stress were found, it is believed that the measured residual tensile stress of 80,000 psi is acceptable for sound electrodeposited chromium.

Residual stresses reported for chromium deposits range from zero upward to the quantities noted in the foregoing, but data are not available to indicate the effects of such stress variations on the fatigue strength of plated specimens.

The fatigue endurance limit of both normalized and hardened SAE X4130 steels were found by H. L. Logan (Ref. 9) to be reduced by chromium plating; the loss being greater for hardened steel. The endurance limits for steel of a given hardness decreased with increased plating bath temperature. Baking the plated specimens at temperatures up to 660 F, for the purpose of removing any effects of hydrogen, further reduced their fatigue strength. When the baking temperature was increased to 825 F, the fatigue strength was increased but not sufficiently to restore the endurance limit to that of the unplated hardened steel specimens.

Damaging effects of chromium on the fatigue strength of the plated steel are attributed to residual tensile stresses in the deposited chromium. These stresses are shown to be increased by low temperature baking, but when baked at 750 to 825 F they are partly relieved.

Fatigue endurance limits of unplated and chromium plated steel specimens of various analyses, hardnesses, plate thicknesses, and current densities are

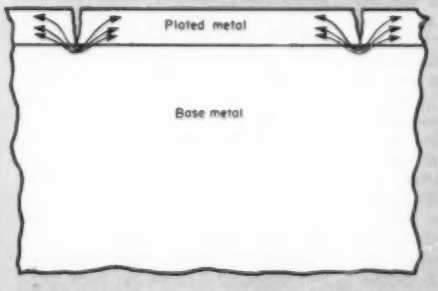


Fig. 3—When cracks form in tensile stressed plated metal residual stress is locally transferred to the base metal.

Table II—Residual Stress in Electrodeposited Metals

Spec. No.	Metal Deposited	Stress, psi	Bath Temp, F	Amp per sq ft
1	Nickel	26,000 tensile	68	10
2	Copper	Nearly zero	95	30
3	Zinc	4,000 comp	65	10
4	Lead	Nearly zero	65	10

Table III—Specimens Plated With Alternating Current Superimposed Upon Direct Current

Spec. No.	Metal Deposited	Stress, psi	Bath Temp, F	Amp per sq ft	
				DC	AC on DC
5	Nickel	8,300	122	10	22
6	Nickel	4,900	122	10	35.7

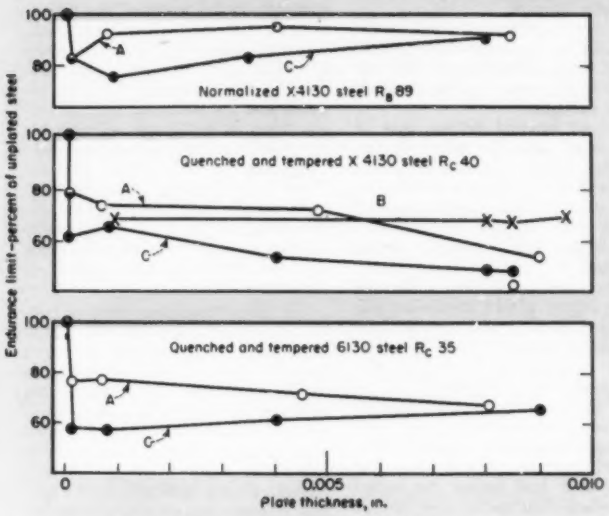


Fig. 4 — Fatigue strength loss from chromium plated on three steels under different temperatures and current densities. Legion: A=130 F and 200 amp per sq ft; B=130 F and 350 amp per sq ft; C=160 F and 1000 amp per sq ft

graphically recorded in Fig. 4, which is from Logan's original publication.

The fatigue data shown in Fig. 1 were obtained as a part of an extensive investigation conducted by Lea (Ref. 1) to measure hydrogen penetration into metal cathodes and its effect upon the tensile and fatigue strengths of steel. He concluded that... "Hydrogen in the cathode does not diminish the resistance to impact of mild steel and its effect on repeated stress seems of itself unimportant. Nickel plating ... lowers the range of repeated stress but this is not apparently due to occluded gases... it would appear that either initial (residual) stresses set up by the deposition or the discontinuities between the metals or, more likely, a crack which early forms in the deposited nickel is the cause of the lowering of the repeated stress range."

Surface Vulnerability and Applied Loads

It is well known that the state of residual stress in thin surface layers has a profound effect on the fatigue strength of repeatedly loaded machine elements and laboratory specimens. Surface residual compressive stresses induced by such processes as shot peening, superficial rolling, nitriding, and carburizing increase the fatigue strength of treated specimens. Conversely, surface residual tensile stresses resulting, under certain conditions, from such processes as grinding, straightening, induction and flame hardening decrease fatigue strength.

These effects have been shown to result from the fact that all surfaces, regardless of uniformity of section and perfection of finish, are weaker in fatigue than sound sub-surface metal (Ref. 10) and that fatigue failures can result only from tensile stresses (Ref. 11). It follows that the tensile stresses in the extra vulnerable surfaces from externally applied loads are reduced in magnitude by surface residual compressive stresses and the fatigue strength of the specimen is thereby increased. Surface residual tensile stresses augment applied tensile stresses and thereby decrease the fatigue strength of the specimen.

It is to be expected, therefore, that electrodeposited metals are harmful to fatigue strength in proportion to the magnitudes of the residual tensile stresses, and are beneficial in proportion to the magnitudes of the residual compressive stresses. Such proportionality is an over simplification because other factors, among which are adhesion, relative yield strength, ductility, and the manner in which the tests are conducted, alter the effective increase or decrease in the applied tensile stresses. The foregoing simple statement, however, will with reservations serve our immediate purpose.

The fatigue tests conducted by Blaklie and Davies, Tables II and III, show that the damage caused by electrodeposited nickel decreased from 28 to 7 percent when the residual tensile stress was reduced from 26,000 psi to 5,000 to 8,000 psi. They also show that when the residual stress in the plated layer was changed from tension to compression, as occurred in zinc deposits, the fatigue strength of the coated steel specimens was greater than the unplated specimens.

To obtain additional information on the effects of residual stresses in electrodeposited hard metals, the Research Laboratories Division of General Motors Corporation initiated a search for processes that would develop residual compressive stresses in plated nickel deposits.

It was believed that several objectives could be attained if means could be found whereby nickel could be consistently deposited in a state of residual compressive stress of controllable magnitude. It was expected that:

A. The loss of fatigue strength that normally occurs in nickel plated machine elements could be avoided, with the further probability that actual increase in fatigue strength would result.

B. Beneficial effect on fatigue of compressively stressed plated metal would provide new evidence that residual stresses have a direct effect on the fatigue strength of metals. Since the base metal would not be mechanically altered by the plating operation, any resulting changes in fatigue strength could not be confused with effects of work hardening.

C. The resistance to rusting of plated steel surfaces could be improved by depositing the plated metals in a state of compression. The plated layers would be more dense, decreased porosity would be expected, and spontaneous (stress corrosion) cracking would be avoided.

The cooperation of the Electro-Chemical Department of the Research Laboratories Division, General Motors Corporation, was solicited in an investigation to determine the validity of the foregoing assumptions.

It was anticipated that in any reasonable exploration of the many variables numerous tests would be required and, therefore, a necessary preliminary was the development of means for measuring residual stresses in plated metals. It was important that the

method should be simple, inexpensive and sufficiently accurate to disclose significant differences in residual stress magnitude resulting from minor variations in plating procedures.

The measuring techniques that were used and the results of numerous plating experiments have been reported in considerable detail by W. M. Phillips and F. L. Clifton (Ref. 12). Unfortunately, the residual stresses as originally calculated and published were incorrect but the stress values given herein have been corrected. Although the authors discuss the data from the viewpoint of decorative plating, the experiments are sufficiently complete to serve as guides for those interested in structural uses of electrodeposited nickel.

Residual Stress Varies Greatly

The data given in Table IV, which are taken from the Phillips and Clifton report show how variations in Watts' nickel bath affect the magnitudes of residual stresses in nickel when plated on steel. As a result of variations in bath composition, the residual stress is seen to range from a minimum of 5,900 psi tension to a maximum of 43,000 psi tension. Significant stress changes also occur with variations in bath temperature and with the thickness of the plated layers. Note the great increase in residual stress when the bath was contaminated with iron.

Also taken from the Phillips and Clifton report are the data given in Table V except that stresses have been re-calculated to eliminate errors in the original publication. This table shows the residual stresses in nickel deposits from various proprietary baths. For commercial reasons these baths are identified by code letters.

The original engineering objective was to find means whereby residual compressive stresses could be developed in hard metal deposits. This goal was attained by nickel deposited on steel from the proprietary baths, C, D, E, F, H, and J, Table V, and by nickel deposited on phosphor bronze from as many of these baths as were tested.

The residual stresses in nickel deposited on steel from the proprietary baths, Table V, range from 70,000 psi tension to 9,700 psi compression for a total variation of nearly 80,000 psi. As in the Watts bath, significant stress changes occurred with variations in bath temperatures. It is, perhaps, important to note that with baths A and B the residual stress increases as the bath temperature is reduced, while

Table IV—Residual Stresses in Nickel Deposited on Steel Base From Watts Bath

Test No.	Bath composition (pH adjusted H_3BO_3 and $NiCO_3$)	pH	Temp, F	Current density, amp/sq ft	Thickness, in.	Calculated stress, psi
1	$NiSO_4$.32 oz/gal	2.8	135	30	0.002	9,500
2	" "	5.3	135	30	"	19,000
3	" " $NiCl_2$.4 oz/gal	2.8	135	30	"	10,700
4	" " " "	5.3	135	30	"	13,000
5	" " " " H_3BO_3.4 oz/gal	2.8	135	30	"	5,900
6	" " " " " "	5.3	135	30	"	13,500
7	Same as No. 5 plus H_2O_2.0.475 oz/gal	2.0	135	48	"	12,700
8	" " " 0.950 "	"	"	"	"	9,500
9	" " " 1.425 "	"	"	"	"	5,900
10	$NiSO_4$.32 oz/gal; H_3BO_3.4 oz/gal	"	"	"	"	9,500
11	" " " " $NiCl_2$.0.5 oz/gal	"	"	"	"	9,500
12	" " " " " 1.0 "	"	"	"	"	9,000
13	" " " " " 2.0 "	"	"	"	"	6,200
14	" " " " " 4.0 "	"	"	"	"	7,200
15	" " " " " 8.0 "	"	"	"	"	11,400
16	" " " " " 16.0 "	"	"	"	"	13,200
17	" " " " " 24.0 "	"	"	"	"	20,000
18	Same as No. 7	2.5	150	"	"	9,400
19	" "	"	130	"	"	9,400
20	" "	"	112	"	"	13,400
21	" "	4.0	150	"	"	10,000
22	" "	"	130	"	"	9,500
23	" "	"	112	"	"	10,000
24	" "	5.4	150	30	"	14,500
25	" "	"	130	"	"	13,200
26	" "	"	112	"	"	19,200
27	" "	2.8	150	"	"	9,200
28	" "	"	"	48	"	9,200
29	" "	5.3	"	30	0.000250	27,200
30	" "	"	"	30	0.00052	26,200
31	" "	"	"	"	0.000745	25,200
32	" "	"	"	"	0.00105	24,200
33	" "	"	"	"	0.00194	13,200
34	" "	"	"	"	0.00275	12,200
35	" " plus Fe, 0.275 oz/gal	2.5	"	"	0.002	43,200
36	" " 0.550 oz/gal	2.5	"	"	"	37,200

No agitation, except solution agitation in Test No. 28.
Calculated stresses in deposit from Test No. 7; 10,400 psi when applied on bronze, 11,100 when applied on brass.
All deposits had good ductility except those obtained in Tests Nos. 35 and 36.

Table V—Residual Stress in Nickel Deposits from Proprietary Baths

Note: Deposit thickness = 0.002 in.; Rec. make-up = Recommended make-up

Test No.	Type of Bath	Composition	pH	Temp, F	Current density, amp/sq ft	Agitation	Change of deflection, in.	Calcul. stress, psi		Ductility
								Steel base	Bronze base	
1	A	Rec. make-up less additions	3.75	150	48	Solution	0.0043	14,000		Good
2	"	Plus addition No. 1	3.75	150	48	"	0.0060	19,500		"
3	"	Plus additions Nos. 1 and 2	3.75	150	48	"	0.0054	17,500		"
4	"	Plus additions Nos. 1, 2, 3	3.75	150	48	"	0.0132	59,000		"
5	"	Plus additions Nos. 1, 2, 3, 4	3.75	150	48	"	0.0230	70,000	61,000	Bad
6	"	Rec. make-up	3.75	150	48	"	0.0100	52,000	80,000	"
7	"	" "	3.75	140	48	"	0.0159	52,000	51,200	"
8	"	" "	3.75	130	48	"	0.0177	57,000	54,000	"
9	B	" "	2.6	160	48	"	0.0055	16,000		Fair
10	"	" "	2.6	140	48	"	0.0072	28,700		"
11	C	" "	3.0	140	48	None	0.00055	1,800	− 3,000	Good
12	"	" "	3.0	130	48	"	0.00008	0	− 2,200	"
13	"	" "	3.0	120	48	"	−0.0014	− 4,500	− 7,400	"
14	D	" "	3.5	125	48	"	−0.00079	− 2,600	− 2,200	Bad
15	E	" "	4.0	135	48	Solution	−0.0030	− 9,700	−12,000	Fair
16	F	" "	3.5	135	48	"	−0.0030	− 9,700	−10,000	"
17	G	" "	4.0	130	48	None	0.0057	18,800		Bad
18	"	" "	4.0	120	30	"	0.0059	19,100		"
19	H	" "	3.1	140	48	"	−0.0012	− 3,900		Fair
20	I	" "	3.0	135	25	"	0.0052	25,600		Good
21	"	" "	3.0	135	48	"	0.00420	13,800		"
22	"	" "	3.0	135	96	"	0.0043	13,900		"
23	J	" "	2.8	135	48	"	−0.00115	− 3,720	− 6,000	"

Calculated stress in deposit on brass from Test No. 5 was 51,000 psi.

Table VI—Procedure for Compressive Plating

CLEANING

1. Degrease
2. Cathodic clean 3 minutes
3. Hand scrub with pumice
4. Cathodic clean 30 seconds
5. Water rinse
6. Anodic treat in concentrated H_2SO_4 at 6 volts for 1 minute
7. Water rinse

PLATING

1. Plate at 40 amp per sq ft for required time to deposit desired thickness. 1200 amp min per sq ft equals 0.001 in. of nickel. Rotate specimen to obtain uniform plate thickness.

2. SOLUTION A. A bright nickel solution having the following composition:

Single nickel salts, $NiSO_4 \cdot 6H_2O$	40 oz/gal
Nickel chloride, $NiCl_2 \cdot 6H_2O$	8 oz/gal
Boric acid, H_3BO_3	5 oz/gal
Brightener A	0.125% by volume
Non-pitter	0.08 oz/gal
Brightener B	0.8 oz/gal

pH 3.5 to 4.8, temp 115 to 140 F

2. SOLUTION B. A newer bright nickel solution that is easier to control. It will probably give results similar to that of Solution A.

Note: With Solution B, residual compressive stress of 5,400 psi has been measured.

with bath C the opposite is true. With baths G and I, the residual stress decreases as current density is increased.

The Phillips and Clifton report shows that nickel deposited in a state of low tensile stress or in residual compression did not crack in the salt spray test as did specimens in which the residual tensile stress was relatively great. The tests were not, however, sufficiently numerous or varied to determine whether corrosion resistance increases with the magnitude of the residual compressive stress as was expected. This probability remains to be explored.

It was not possible immediately to conduct fatigue tests at the Research Laboratories Division, General Motors Corporation, to determine the effects of residual compressive stresses in nickel deposits on steel specimens. It was learned, however, that a U. S. Government Laboratory was conducting a series of tests to measure the extent of fatigue damage resulting from nickel plating and the effect of shot peening specimens after plating and the base metal before plating.

Shot peening after plating had previously (Ref. 13) been found effective in restoring fatigue strength to steel specimens plated with tensile stressed hard as well as soft nickel.

Controlled Stress in Nickel Deposits

The Research Laboratories Division, General Motors Corporation, offered to nickel plate two groups of fatigue specimens for tests by the government laboratory. The plating would be so controlled that the nickel deposits on one group would be residually stressed in tension and on the second group would be residually stressed in compression. This offer was accepted and specimens ready for plating were supplied.

The procedure that was selected for plating the first group of specimens developed residual tensile stress of 25,000 psi, and the process used for the second group developed 6,000 psi residual compressive stress. The plated specimens were returned to the government laboratory where they were fatigue tested in comparison with non-coated, fully polished specimens of the same base steel. The results of these tests are shown in the replotted S N diagram, Fig. 5. The endurance limit of the polished base steel was found to be 45,000 psi, which dropped to 29,000 psi when plated with the 25,000 psi tension stressed nickel.

In contrast to this loss of 35 percent, the specimens plated with nickel stressed to 6,000 psi compression actually indicated a gain in strength. The indicated gain, however, is well within the range of experimental error and, until more data are available, it should be assumed that these compressively stressed nickel plated specimens are approximately equal to the polished base steel.

Although these controlled stress tests or similar tests should be repeated to establish more definitely the variations in the fatigue strength of the three kinds of specimens, the differences shown between tensile and compressive residual stress are sufficiently great to justify the conclusion that fatigue strength of nickel plated specimens is directly affected by the state of residual stress in deposited nickel.

The procedures given in Table VI were used for cleaning and nickel plating the fatigue specimens having residual compressive stress of 6,000 pounds per square inch.

It is important to remember that the fatigue comparisons shown in Fig. 5 were made with specimens in which the base steel was fully polished. It has been shown (Ref. 10) that polishing induces residual compressive stresses sufficiently great (possibly 15,000 to 20,000 psi) to increase the fatigue limit of rotating beam steel specimens 10 to 15 percent.

It would therefore not be expected that the fatigue strength of polished steel specimens plated with nickel would be appreciably increased by plating until the retained residual (See Ref. 10 for definition of "retained residual stress") compressive stress in the nickel coat exceeds the retained residual compressive stress induced by the polishing. It is not probable that this condition prevailed in the specimens plated with nickel stressed 6,000 psi in compression unless the yield strength of the nickel coat exceeded the yield strength of the base steel.

Since under reversed loading, much of the residual compressive stress may be lost by compressive yielding, it is desirable to coat the surface of the base metal with a deposit having a high elastic limit, as well as good adhesion and high residual compressive stress. A coat that possesses these qualities need not have much ductility.

Effectiveness of the residual com-

pressive stress in plated metal is lost unless the bond to the base metal is strong enough to support the stress at the junction of the two metals.

In the experiment conducted by the Research Laboratories Division, General Motors Corporation, the maximum residual compressive stress obtained was 9,700 psi. Since this result was, presumably, an accidental characteristic of one of the proprietary baths, it is probable that residual compressive stress of greater magnitude can be induced by nickel baths developed for that specific purpose. With strongly bonded nickel having residual compressive stress of 15,000 to 20,000 psi, and high yield strength, it should be possible to improve greatly the fatigue strength of machine elements by nickel plating.

The desirability of high yield strength and high hardness suggest that, if chromium can be plated in a state of high residual compression together with high bond strength, it will be superior to nickel for rebuilding and fatigue strengthening purposes. Although no efforts to obtain compressively stressed chromium are known, this field may have been neglected because research along this line the fatigue strength of machine elehas not seemed important.

In rebuilding highly stressed machine parts by electroplating, the sign and the magnitude of the residual stress in the deposited metal should be determined. For this purpose a measuring technique similar to that developed by the Research Laboratories Division, General Motors Corporation, is recommended. At least one measuring specimen should be plated in the same tank with each machine part and the conditions of plating as nearly identical as possible.

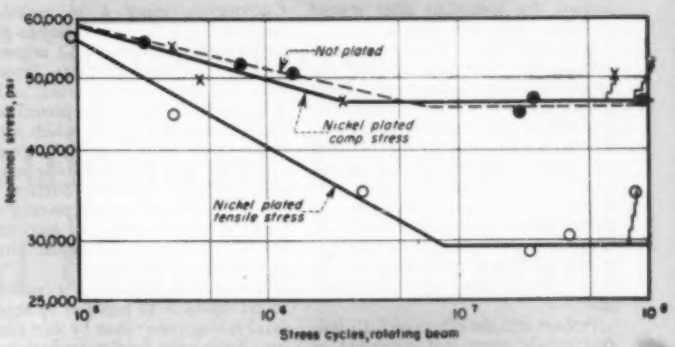


Fig. 5 — Fatigue strength of steel plated with controlled stress in nickel deposit.

Mechanical Prestressing Effective

Although electrodeposited coatings that are residually stressed in compression are more desirable for structural purposes, including protection against corrosion, it is possible to avoid much of the loss of fatigue strength resulting from coatings that are residually stressed in tension. Since fatigue failures occur only from tensile stresses, the extension of cracks formed in the plated metal into the base metal can be prevented by inducing residual compressive stress in the surface of the base before plating. Prestressing of the base metal can be accomplished by shot peening, superficial rolling, and other mechanical and thermal treatments.

The results of prestressing rotating beam fatigue specimens by shot peening prior to chromium plating are shown in the S N diagram, Fig. 6. This diagram has been replotted from data obtained from the same government laboratory that reported the tests shown in Fig. 5. The four plotted curves show:

(a) Curve labeled "Not Plated" is the same as the similarly labeled curve in Fig. 5 and represents rotating beam fatigue strength of fully polished base steel.

(b) Curve labeled "Chrome Plated" shows the fatigue strength of fully polished base metal after plating with chromium.

(c) Curve labeled "Shot Peened" shows the fatigue strength of the unplated base steel after shot peening.

(d) Curve labeled "Peened and Chrome-Plated" shows the effect of induced residual compressive stress in the base steel that was shot peened before the chromium was deposited.

These curves show that the fatigue strength of specimens plated after peening is greater than that of the fully polished base steel but not as great as that of the peened but uncoated base metal. Prestressing is seen to have increased the fatigue strength of chromium plated steel 35 percent.

The same government laboratory also reported a similar series of tests in which nickel (not plated by the Research Laboratories Division, General Motors Corporation) was used in place of chromium. The data are replotted in Fig. 7 in which similarly labeled curves represent the same conditions as are described for Fig. 6. Note however that the "Shot Peened" curve of Fig. 6 is not shown in Fig. 7, but a new curve is added:

(e) Curve labeled "Nickel Plated

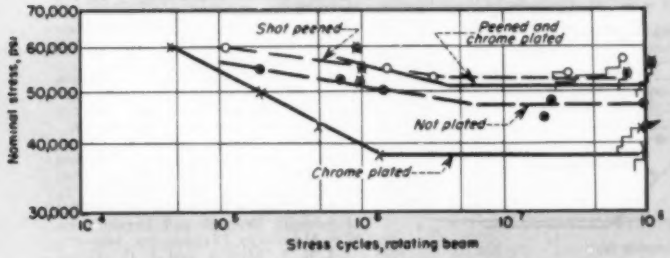


Fig. 6 — Comparison of fatigue strengths of uncoated, chromium plated, shot peened, and peened and chromium plated steel rotating beam specimens.

and Peened" shows the effect of shot peening the specimens after instead of before they were plated.

It is seen that prestressing by shot peening has more than doubled the fatigue strength of the nickel plated specimens. The loss of strength (60 percent) of the unpeened plated specimens as compared to the polished base steel, however, is the greatest known to the author. The magnitude of the residual tensile stress in the plated nickel was not given but, presumably, it was much greater than the 25,000 psi of the equivalent curve of Fig. 5, which shows a loss of 37 percent.

Perhaps it is the effects of high residual tensile stress that prevented as great a strength recovery (41,000 psi) of the peened and plated specimens, Fig. 7, as that (56,000 psi) which occurred in the Fig. 6 equivalent specimens.

Shot peening of the specimens of Fig. 7 was performed by the Research Laboratories Division, General Motors Corporation, using ⅛ in. polished steel bearing balls at a velocity to give an intensity of .006-.008A2 as measured by the Almen standards. Smooth steel balls were used to avoid, as far as possible, damaging the peened surfaces by cuts and bruises, which often occurs when using commercial grades of chilled iron shot containing rough and fractured particles. Surface irregularities caused by shot peening reduce the fatigue strength of specimens to the same extent as similar stress raisers from other causes.

In many applications, it will be found desirable to prestress by superficial rolling rather than by shot peening. Rolling can develop residual compressive stress of exceptional magnitude and surface roughening can be thus avoided. In an O.S.R.D. report (Ref. 14), tools suitable for superficial rolling of various shaped surfaces have been illustrated and briefly described.

Laboratory Tests Often Misleading

Whether prestressing is induced by suitable plating processes or by mechanical operations before or after plating, the effectiveness of the residual stress in increasing fatigue strength cannot be measured by arbitrary repeated loading schedules. Preferred laboratory fatigue specimens apply reversed loads of equal magnitude whether the tests are in bending, torsion, or push-pull. Specimens subjected to reversed stresses lose substantial parts and sometimes all of the compressive residual stress by compressive yielding (Ref. 10) of the surface or tensile yielding of the core. The result is loss of fatigue strength in as great or greater proportion than the loss of residual compressive stress.

Few machine parts operating in normal service are subjected to reversed loading. Among the parts on which the load is reversed, plus and minus loads of equal magnitude are rarely found. The true effectiveness of prestressing treatments applied to machine parts can only be found by actual service use of the treated part or, less accurately, by a laboratory test in which the machine part is subjected to a loading schedule similar to that which occurs in normal service.

A reasonably reliable laboratory test loading schedule requires that the normal service loads have previously been determined by suitable strain measuring instruments. For critical applications beware of "simulated service" loading schedules. Such tests when not supported by actual measurements and service experience will often serve only to deceive the experimenter. Unproved simulated tests should be regarded as counterfeit tests. A large percentage of laboratory tests fall into this category.

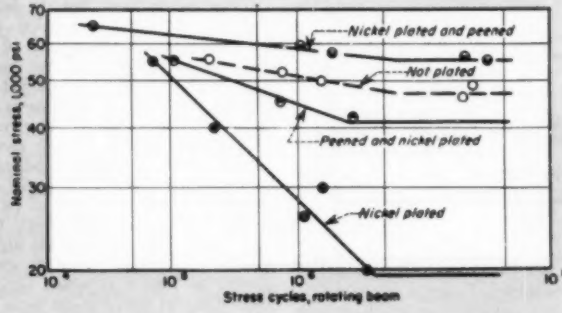


Fig. 7 — Comparison of fatigue strengths of uncoated, nickel plated, peened and nickel plated, and nickel plated and peened steel rotating beam specimens.

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14. R. L. Mattson and J. O. Almen, Effect of Shot Blasting on the Physical Properties of Steel, Final Report, Part III O.S.R.D., No. 6647. Published by National Defense Committee of the Office of Scientific Research and Development, War Metallurgy Division, pp. 25-34.

Electrical Connectors For Equipment Power And Control Circuits

Quick coupling connectors add flexibility to equipment and simplify manufacturing and maintenance. Here are the factors involved in their selection as outlined by the application engineering staff of the Scintilla Magneto Division, Bendix Aviation Corporation.

THERE ARE TWO BASIC CLASSES of plug-type electrical connectors; an inexpensive commercial type, which is adequate when only two or three leads are required, when a relatively high voltage drop across terminals can be tolerated, and when no unusual conditions will be encountered in service; and a precision-type connector, which is a highly engineered device that is available with from 1 to 46—or more—contacts. These latter devices have a voltage drop across terminals less than the drop across an equivalent length of wire; are made with pin tolerances of ± 0.0001 in.; and are designed to withstand severe exposure to dust, moisture, grease, vibration and heat.

Like precision hydraulic couplings, these electrical connectors were first applied in large numbers in aircraft to permit quick connect and disconnect of electrical accessories. Since than, applications have been broadened to include industrial equipment such as machine tools, commercial equipment such as floor sanders and business machines, and all types of military equipment for marine, ordnance, and aircraft use.

Selecting the Right Connector

In selecting a connector, the first requirement to consider is the number and size of contacts. The second is the size and shape of shell and type of auxiliary fitting that should be used. And last but equally important are the special electrical or mechanical features that are necessary for satisfactory operation in service.

NUMBER OF CONDUCTORS AND CONTACT SIZE: As previously stated, the number of conductors for a connector may vary from 1 to 46. If production volume is sufficient, there is no reason why units with a large number of leads cannot be designed and manufactured, but usually it is more economical to split the wires into two or more groups, using a standard connector for each.

Each connector is designed for a specific operating voltage, and the contact size naturally depends on the amount of current that must be handled at that voltage. Frequently, there are several different pin sizes on each connector: Large sizes to handle the main power supply, intermediate sizes for power supply to auxiliaries, and small sizes for signal and control currents. The current capacity and voltage ratings standardized by AN specifications for various contact sizes and contact arrangement is given in Table I.

INSULATION RESISTANCE OF INSERT: Since precision type connectors are widely used by the military, the insulating material also generally follows AN specifications. In broad terms, these require that the material have a dielectric strength of 100 volts per mil. Actually, the synthetic neoprene rubber that is used by some manufacturers is superior to this. For example, the Bendix material has a resistance of 300 maximum volts per mil. In practice, the voltage rating on connectors is far under this maximum limit.

CONNECTOR RECEPTACLE AND PLUG: Type of receptacle and plug is another variable in connector selection, Fig. 1. The wall connector is designed specifically for flange mounting on bulkheads and partitions and can be provided with accessory devices such as gaskets to obtain better radio shielding and moisture resistance; rubber grommets to prevent wire bending, breakage and entrance of foreign matter; and cable clamps or elbows to give mechanical support to the wires. The line connector is similar in design but has no flange; it is used specifically to provide a disconnection in a line where no mechanical support is available. The box receptacle is similar to the wall type but is un-

Table I—Electrical Contact Data

Contact Size	Rated Current Amperes	AN Voltage Drop	AN Service	Limiting Operating Voltage at Sea Level		Effective Creepage Distance Nom.	Mechanical Spacing Nom.
				DC	AC rms		
16M	20	21	Inst.	70	50	1/16	—
16	20	21	A	200	150	1/8	1/16
12	35	20	D	500	275	3/16	1/8
8	60	12	E	650	350	1/4	3/16
4	110	10	B	750	500	5/16	1/4
0	200	10	C	3000	2100	1	5/16

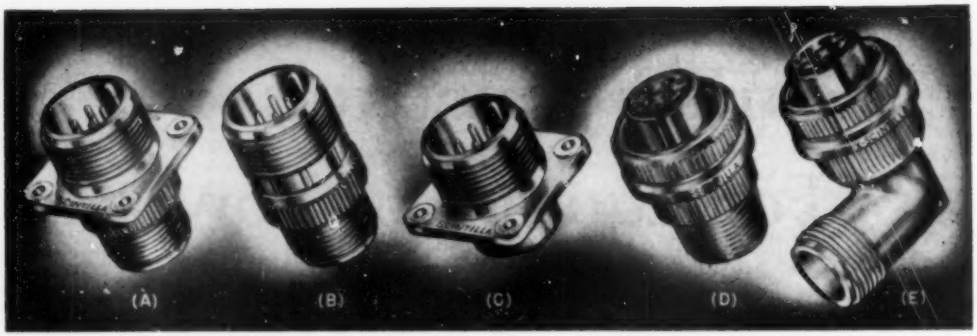


Fig. 1—Standard types of precision receptacles and plugs; (A) Wall mounted receptacle for bulkheads and partitions; (B) line receptacle for line disconnection; (C) box receptacle for equipment housings which is similar to the wall mounted type but unthreaded on the back; (D) straight plug; and (E) angular plug.

threaded on the back and generally is not used with accessories. The size of any of these shells is designated by the size of the coupling thread in sixteenths of an inch.

Insofar as plugs are concerned, it is necessary for the designer to note only two items not previously mentioned: Whether a straight or angular type plug is required, and whether the plug or the receptacle shell is to carry socket contacts.

There is some difference between shells and plugs for moisture proof service and those for standard operating conditions. Standard units usually are die cast and have a flat seat between the plug and receptacle. The other type is fully machined from bar stock or forgings and has a ball and cone seat to provide line contact.

This latter construction also is used for pressurized connectors and for radio shielding under severe conditions. For example, the Bureau of Ships specifies a ball and cone seat whenever radio shielded units must be provided. However, in other applications, a long tapered seat can be used, and for normal service, a gasketed connector of the standard type is satisfactory.

Specific Requirements

Besides the more obvious electrical and mechanical requirements, a connector often must withstand special conditions that will be encountered in service. Military specifications require that they:

1. Resist the effects of vibration and temperature, and withstand repeated assembly and disassembly.
2. Resist submersion in water or other fluids.
3. Withstand pressurization and atmospheric corrosion.

Under any of these conditions, the electrical connector has to insure continuous operation, a minimum voltage drop in the circuit, and high dielectric quality in the insert material.

VIBRATION: The simplest way to indicate vibration resistance is to quote from military specification Mil-C-5015.

"The apparatus shall consist of a suitable device or devices for mounting and vibrating items of equivalent mass linearly through the following ranges:

1. 0.100 inch double amplitude (total excursion) from 5 to 10 cycles per second.
2. 0.060 inch double amplitude from 10 to 60 cycles per second.
3. 11g vibratory acceleration from 60 to 75 cycles per second.
4. 15g vibratory acceleration from 75 to 100 cycles per second.
5. 20g vibratory acceleration from 100 to 500 cycles per second.
6. 50g vibratory acceleration at 150 cycles per second.

"The test specimen shall be mounted on the apparatus in a position dynamically similar to the most severe mounting likely to be used in service. Resonant frequencies of the specimen or component parts shall be determined by varying the frequency of applied vibrations slowly through the specified frequency range. This procedure shall be followed successively for vibration applied along three mutually perpendicular axes of the test specimen. If resonant frequencies are encountered, the specimen shall be vibrated along three mutually perpendicular axes of the test specimen. Whenever practicable the functioning of the test specimen shall be checked concurrently with the operation of scanning the frequency range for resonant frequencies. If resonant frequencies are encountered, the specimen shall be vibrated along three mutually perpendicular axes for 4 hours. The specimen shall then be vibrated for 50 hours along each of its three mutually perpendicular axes at an applied force of 50g and a frequency of 150 cycles per second. The specimen shall be functioning in accordance with the provisions of this specification during the entire test period whenever practicable. There shall be no failures of material or broken cables within the connector as the result of this test. There shall be no evidence of failure of the contacts to maintain electrical continuity during this test."

Perhaps the entire subject of vibration can best be summed up by stating that standard connectors have withstood service on trans-atlantic aircraft for 600 hr without failure under vibratory conditions much more severe than are likely to be encountered in ordinary industrial equipment. Usually, the weak point from the vibration standpoint is the soldered joint between the connector contact and the wire. Some types of solderless connectors are available and for severe service, should be investigated.

PRESSURIZATION: The Army and Navy have been interested in pressurization because of the desire to fly at altitudes where life will not be sustained unless pressure is provided equivalent to that of sea level, or thereabouts. There are other reasons for pressurization. One engine manufacturer uses meter equipment which requires that a connector be mounted on the housing. The housing has 5 psi oil pressure behind it and operates at a temperature of 180 F. A pressurized connector is an absolute necessity for an application of this sort.

The synthetic rubber used in the insert inherently is a good sealing

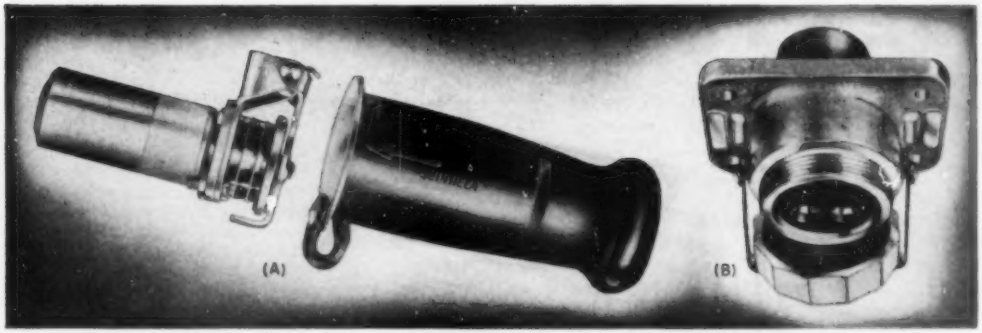


Fig. 2—Two special types of precision electrical connectors: (B) Slave receptacle for heavy duty vehicles especially adaptable when dust and dirt are present; and (A) quick disconnect plug and receptacle, which in an emergency can be disconnected by a pull on the lead. This latter connector is designed for heavy vehicles.

medium. The cost of pressurized connectors of this type is appreciably below those actually sealed by fusing glass or ceramic materials to contacts and metal shells.

CORROSION RESISTANCE: The aluminum shells on connectors and plugs can be finished in any of several ways. Standard units are electroplated, usually with a cadmium plate, but they can also be anodized, varnished, or finished by a chemical dip.

TEMPERATURE: Precision connectors usually are rated for operating temperatures between —67F and +185F. The neoprene insert material is not affected by thermal cycling in this range. In addition, flame barrier connectors can be provided which will withstand direct exposure to an open flame of 2,000 F for 5 minutes without permitting flame passage.

There are, of course, many other specifications that connectors must meet when designed for military use, but details of these are beyond the scope of this article. In addition, strictly special connectors, Fig. 2, can be obtained for many unusual service conditions. The point is, however, that precision connectors of any type can be used for equipment ranging from control panels on machines to aircraft accessories or automatic computers, the advantages being:

1. Simplified manufacture and repair, since individual parts can be prefabricated, wiring can be preformed, and defective components can be quickly removed from a system.
2. Increased safety, since components can be easily disconnected in case of fire or explosion.
3. Improved appearance, since all wiring is grouped at one location.

Bureau Tests Special Lubricants

STATIC FRICTION TESTS of a number of relatively new special lubricants, in combination with various metals, have recently been completed at the National Bureau of Standards. The effect of metal composition and of metal surface finish on static friction was also investigated in the course of these studies.

Static friction coefficients are indices of the ease with which one of a pair of metal surfaces (lubricated, in the present case) will start to slide in relation to the opposing surface. While low static friction is desirable in many applications, it cannot be taken as an indication of over-all lubricant efficiency.

Some 20 special lubricants, principally chlorinated and fluorinated hydrocarbons with and without various additives, were tested. Additives investigated included graphite, molybdenum disulfide, zinc oxide, boron nitride, and an oxidized petroleum compound. An SAE 10 mineral lubricating oil was used as a reference or basis of comparison. Metal surfaces used in various combinations for the tests were stainless steel, carbon steel, cast iron, aluminum alloy, and chromium plate. An inclined plane test apparatus of conventional design was used.

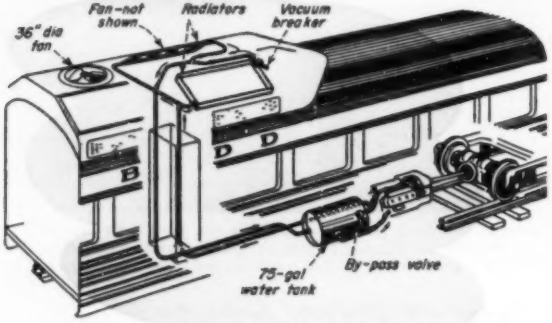
Lowest static friction was shown, in general, by test lubricants containing molybdenum disulfide—closely followed by a mineral lubricating grease, dry molybdenum disulfide, and a fluorinated hydrocarbon with graphite additive. Lubricants for which the most favorable data were obtained showed static friction about 50 to 60 percent less than the SAE 10 reference oil. A lubricant containing an oxidized petroleum compound, and one containing a silicone grease, gave slightly less friction than the SAE 10 oil. Higher friction than the reference oil was shown by the chlorinated and fluorinated lubricants without additives, and by the remaining special lubricants.

Some of the metal combinations used ranked about the same in friction, relative to other metal combinations, regardless of the lubricant with which they were tested. In the case of certain metal combinations, on the other hand, the relative rank of the combination depended to a much greater extent on the lubricant used.

Certain heat-treated stainless steel combinations showed, with most lubricants, the lowest friction values. With a few lubricants, a chromium-plated rider on a heat-treated stainless steel plate gave low friction values comparable to those for the stainless steel combinations. Dependence of relative friction rank on the lubricant used was especially great in the case of an Alcoa 214 plate used with either a chromium-plated rider or a stainless steel rider, and also for the combination of a 1050 steel rider and a cast iron plate. Each of these combinations ranked high in friction when used with one or more lubricants, but low when tested with other lubricants.

Polished surfaces sliding on lapped surfaces tended to give lower friction and less variation than ground surfaces sliding on ground surfaces.

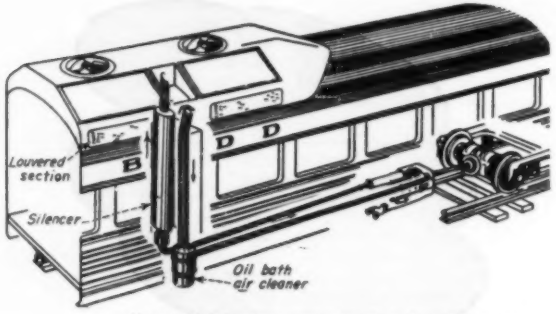
DESIGN FEATURES



Cooling system—Engine-driven centrifugal pump forces water through transmission and engine coolers to engine block and head. At 180F, valve by-passes water through roof radiator and back to tank.

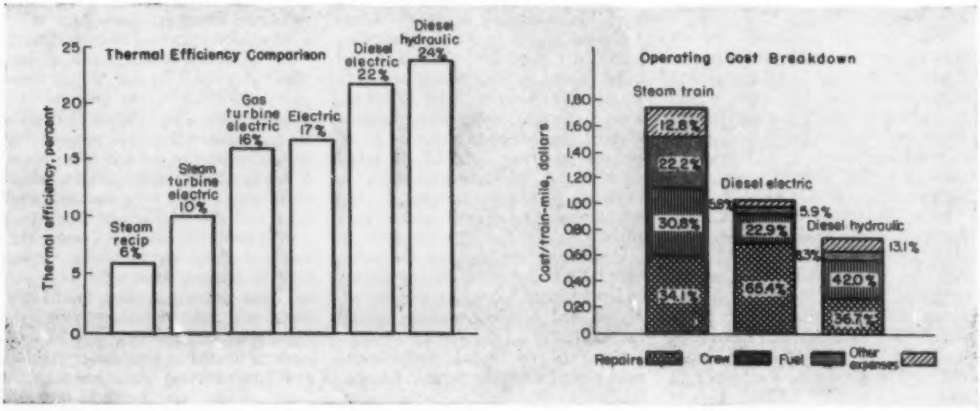
CAR BODY is primarily a modified box beam of stainless steel with a longitudinally corrugated roof welded to curved transverse Z-shaped carlines. Raised dome houses engine coolant radiators and fans, as well as engine air intake and exhaust pipes. Sideframes are built as modified plate girder shear-carrying members connecting the roof and floor. These are the main chord members of the box beam. Car body has an overall balanced strength to meet any type of normal or impact loads without individual weak spots. Alternate floor plans permit variable arrangement of baggage compartments as well as passenger space.

Torque Converter Ups Efficiency

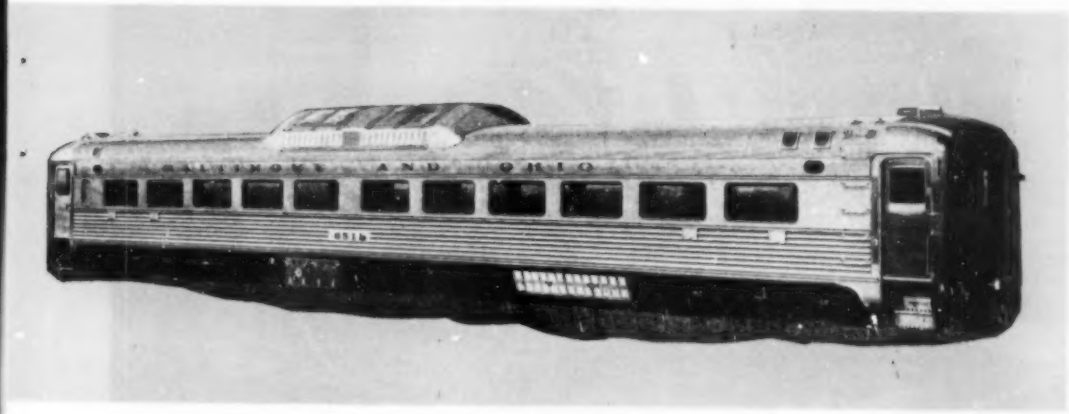


Air and exhaust systems—Combustion air is drawn from roof through oil-bath cleaner to engine by an engine-mounted centrifugal blower. Exhaust is through stainless steel silencer.

As the acceptance by the railroads of the multiple-unit diesel locomotive has grown, so has the interest in self-contained commuter trains. One reason is the Budd Company's RDC (Rail Diesel Car) which appears to be one solution to railroad passenger traffic problems—close scheduling of long trains over a short haul at reduced cost per mile. Cost per mile of a five-car RDC train is less than 40 cents per car, while that of a steam locomotive with two cars is $1.80 per mile. This cost reduc-

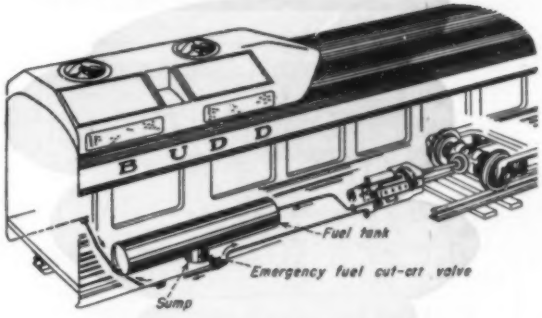


IN NEW PRODUCTS

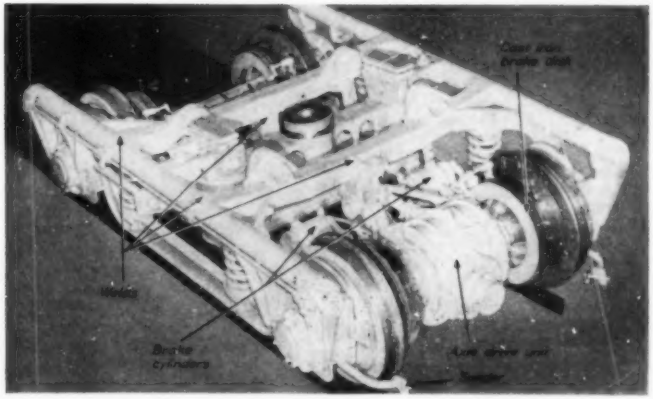


# of Unit Diesel Rail Car

tion can be attributed largely to the fact that the loaded weight of the 90-passenger RDC is about the same as for an empty 56-passenger mainline coach. Two General Motors diesel engines totaling 550 hp power the RDC. Slung under the car floor at 20 deg from the horizontal, these power plants drive one axle in each truck through a hydraulic torque converter and gear box. About 12,000-lb is thus saved when a comparison is made with engine-generator-electric motor cars.



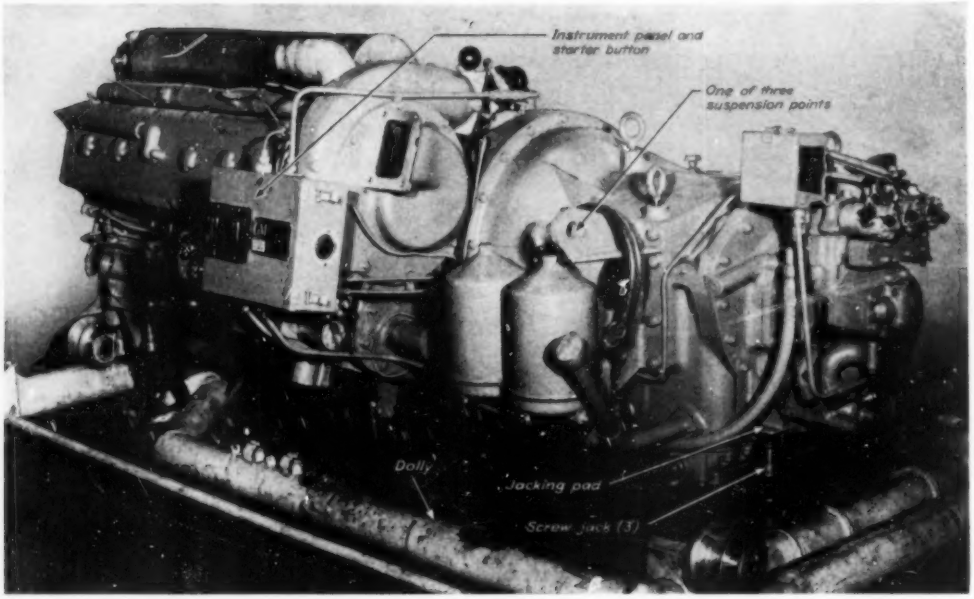
Fuel system—Single 250 gal tank serves both diesel engines. Standard strainer, filter and engine-driven pumps are used.

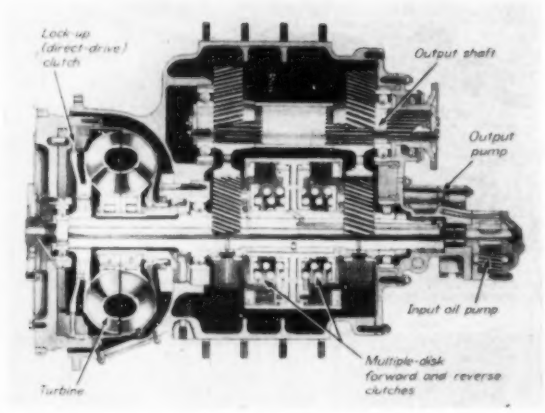


THE RDC TRUCKS are 4-wheel, single equalizer, single bolster, swing hanger type equipped with coil bolster and equalizer springs, and both longitudinal and transverse stabilizing rods. To save weight, the truck frame has no end transoms, made possible by absence of clasp brake rigging. Shock absorbers snub vertical bolster motion. Assembly is built up from steel plates, shapes and alloy steel castings welded together. The equalizers are drop forged alloy steel I-beams that are 45 percent lighter in weight than conventional rectangular bar equalizers. Each brake cylinder operates tongs that clamp composition brake shoes against a cast iron brake disk bolted to the hub of each wheel.

(*continued on next page*)

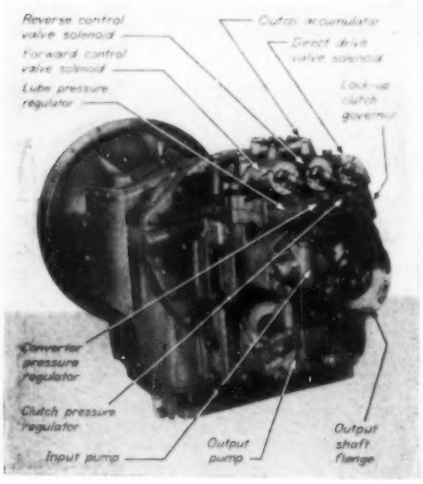
Unit Diesel Rail Car (continued)

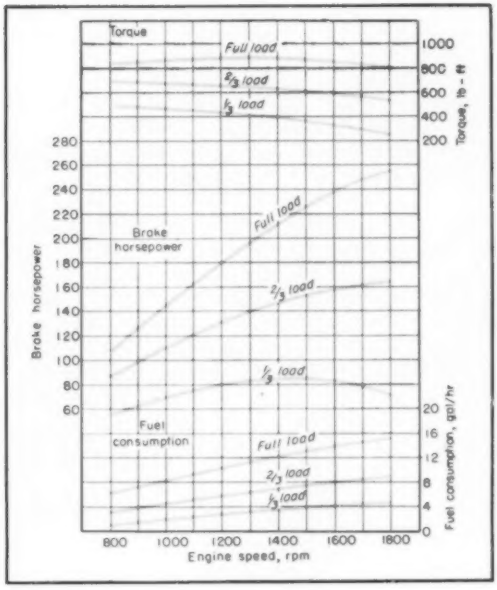




TRANSMISSION CONSISTS OF a four-element, single-stage GM torque converter with two sets of clutch-controlled helical gears for forward and reverse. Gear ratios are 1:1 so that two transmissions can be used—one driving through the forward gear train and the other through the reverse gear train. Secondary function of the gear trains is to allow proper distribution of the gravity center with reference to the centerline of the car drive. The lock-up clutch, which is built into the torus housing, permits shifting the transmission from hydraulic to direct mechanical drive. Converter pump, turbine and stators are precision cast in aluminum. Pump is attached to the engine flywheel so that these two members enclose the converter proper and become a rotating housing.

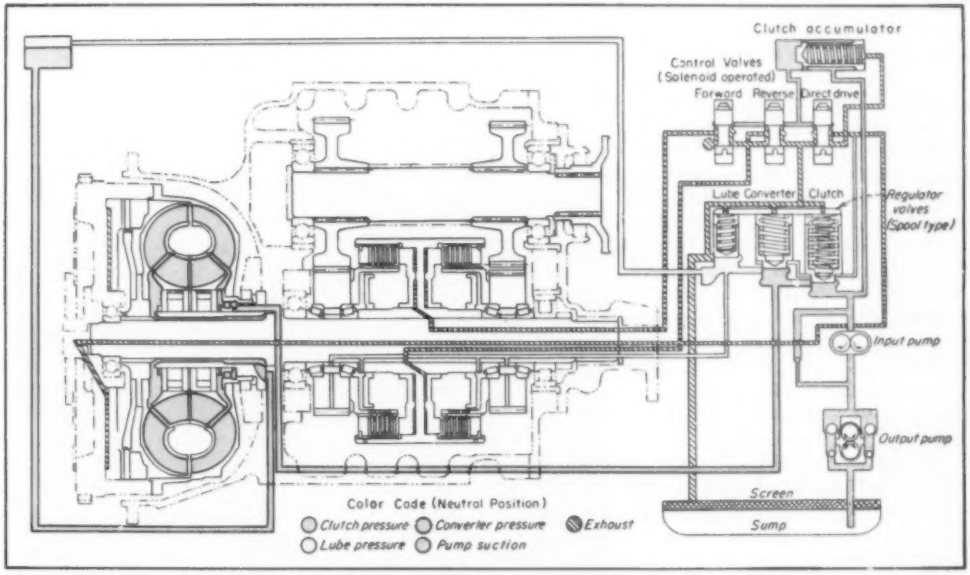
EXTERNAL LOCATION OF OIL PUMPS, hydraulic control valves and governor simplifies servicing. Input oil pump serves its own transmission, while the output pump is car-driven so that, should one of the engine and transmission units be inoperative, the other transmission would still be pressure lubricated by axle drive. The lock-up clutch governor is driven from the output shaft, cutting in between 53 and 56 mph and cutting out between 44 and 47 miles per hour automatically.





EACH OF THE TWO GENERAL MOTORS 6-110 two-cycle, six-cylinder diesel engines is rated at a maximum power of 275 bhp at 1,800 rpm. Bore is 5 in.; stroke, 5.6 in.; displacement, 660 cu in.; and compression ratio, 18:1. An electric throttle control is mounted on the engine governor and connected electrically with a five-position controller in the cab. Position *OFF* allows the engine to idle with all transmission clutches disengaged; *No. 1* permits engagement of clutches with no change in throttle; positions *No. 2* and *No. 3* are part throttle adjustments completely independent and unaffected by the governor (usually set for approximately $\frac{1}{3}$ and $\frac{2}{3}$ power); and position *No 4* is for full throttle. A two-hour engine change is made possible by the use of quick disconnects for all engine services, simple attachment of the power unit to car body, and a special dolly for handling the power unit. Quick disconnects consist of fire hose type water connections, self-sealing disconnects in the fuel lines, toggle clamp connectors for air and exhaust, and plug type electrical connectors. Three-point rubber suspension is used to attach the engine and transmission unit to the car. Two of the connections are made by bolts at the transmission hangers and the third is a stirrup that swings under a bracket attached to the front of the engine. The dolly rides on three rollers.

CURVES AT LEFT show one-third, two-thirds and full-throttle performance of GM 6-110 diesel engine.

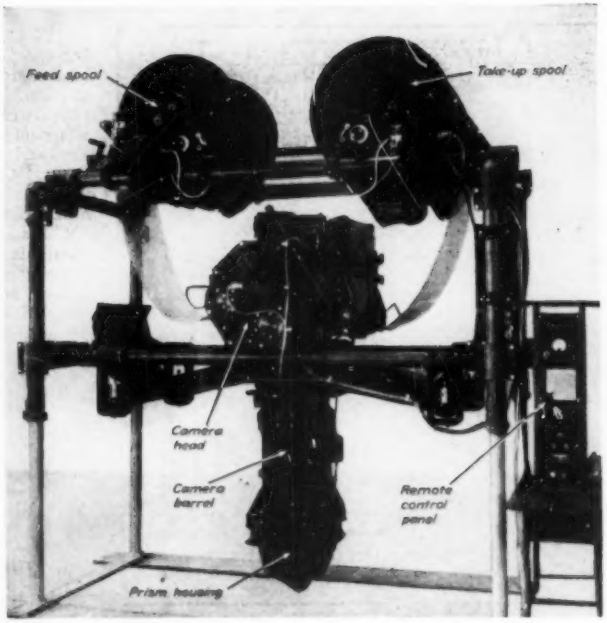


OIL FROM THE INPUT PUMP goes to the lower valve body and is regulated at 115 to 125 psi for forward and reverse clutches by the spool-type pressure relief valve when in neutral or converter drive. Excess oil from this clutch valve is regulated in the converter circuit at 60 to 70 psi by the second spool valve. Bleed-off from this converter valve is metered at 12 to 15 psi by the lubrication regulator valve. During shifts into forward or reverse gear, clutch pressure drops momentarily to about 50 psi and the accumulator valve outlet port is closed. After the clutch piston engages the multiple-disk clutch, oil pressure increases and the accumulator valve shuts off oil flow except for the small amount passing through metering holes in the valve. As the clutch engages, accumulator valve continues back to original position, thus, with the metering action, softening the engagement.

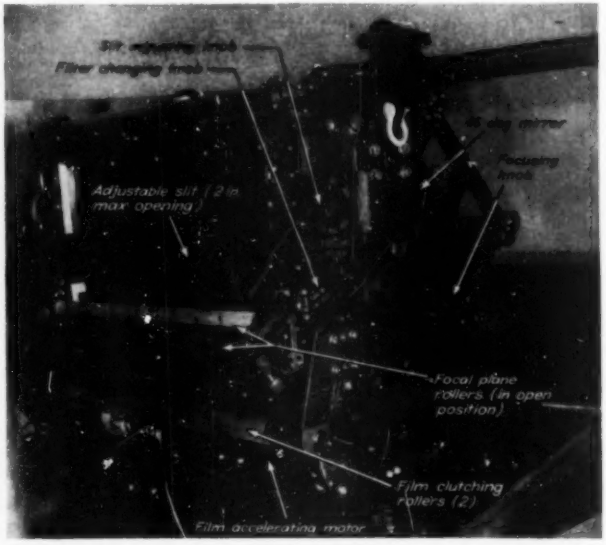
Panoramic Camera has Electronic Controls

By precisely synchronizing the movements of a 90-lb scanning prism and an 18-in.-wide strip of photographic film, a new aerial reconnaisance camera will reproduce from an altitude of 40,000 ft detailed ground patterns that stretch from horizon to horizon. This transverse panoramic camera has a five element 48-in. focal length lens that is twice the size of many now being used. As the plane travels over a given terrain, the twin dove prism rotates across the line of flight through a 180-deg arc and, with the lens system, "wipes" the image onto the film as it is pulled over a 2-in.-wide slit. Prism and film drive rollers are driven through a series of toothed rubber-and-fabric belts from a main drive motor. A third belt take-off at the rear of this drive actuates a compensator mechanism that shifts the film plane to allow for drift of the image caused by the forward motion of the plane and position of the prism. Once the camera is focused, and set for altitude and ground speed, electronic servo systems control the camera remotely. According to the makers, Perkins-Elmer Corporation of Norwalk, Connecticut, an area as large as the state of Pennsylvania can be photographed in less than a day on a single roll of film.

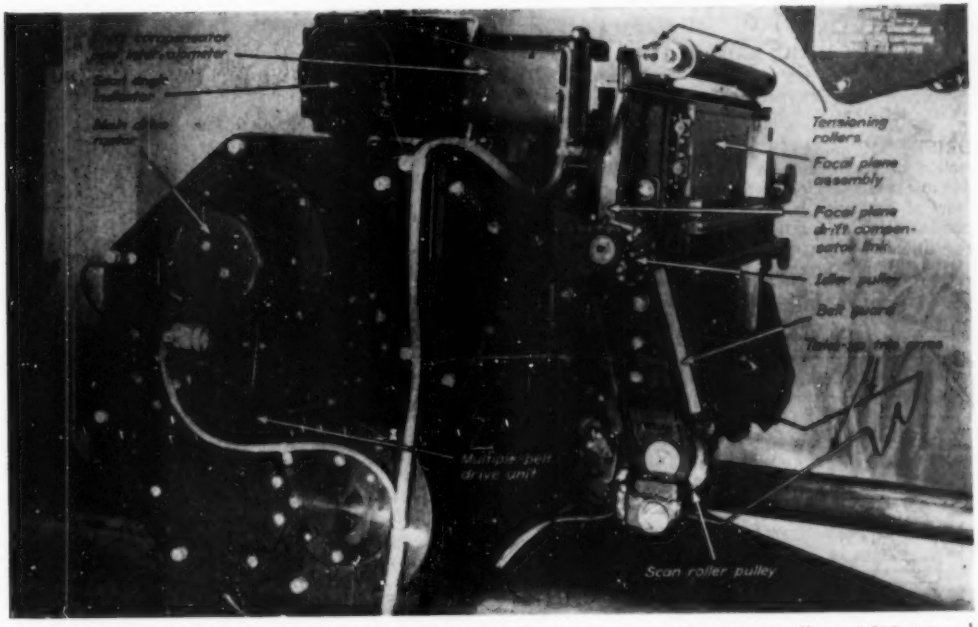
The new camera was developed in cooperation with the Photographic Laboratory of the U. S. Air Force at Wright Field, Dayton, Ohio. Dr. James G. Baker of Harvard University proposed and developed the lens system, and adapted it for use in the camera.



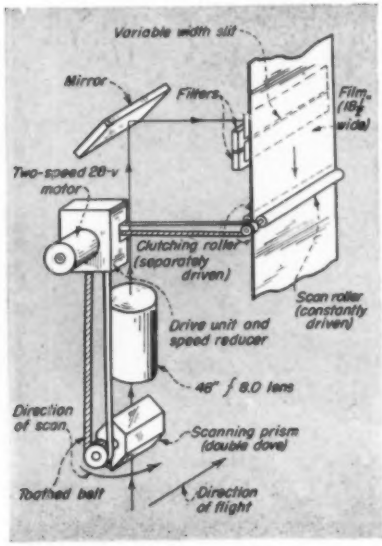
CAMERA HEAD and film spools are mounted in light-tight compartment within fuselage of airplane. Camera barrel extends between floor and skin of plane, and prism rotates in blister in plane's belly. Remote control panel is outside dark room where operator sets controls.



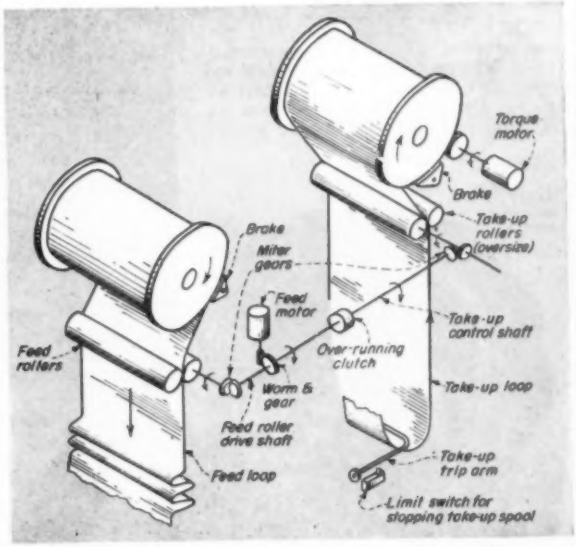
FILM ACCELERATING MOTOR drives second clutching roller (behind roller shown) and brings film up to speed at start of scan. 2-in. focal plane slit is adjustable to give exposure range from 1/50 to 1,000 sec. "Minus" blue or red aero filter is used depending on atmosphere conditions prevailing during a given flight.



TAKE-OFFS at rear drive unit actuate drift compensator and intervalometer at 20 rpm, scan roller at 1,200 rpm and prism drive at 10 rpm. Focal plane assembly is mounted in four corner trunnions and oscillates around a center-line normal to surface of film. To seal out light from the camera head, nylon brushes are used at the points where the prism drive belt enters and leaves the camera head. A skirt in the floor mates with the light baffle ring.



SCHEMATIC of camera optics and mechanism in which accuracy requirements of prism and scan roller velocities are better than 0.1 percent to insure precise synchronization of image and film movements.

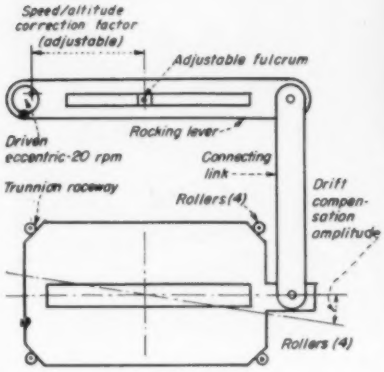


FEED MOTOR controls entire feed and take-up system. Motor speed is maintained by d-c thyratron and computer in control panel. Induction type torque motor turns take-up spool as take-up rollers meter film. When film loop becomes too small, limit switch stops torque motor and feed system continues operating. (*continued on next page*)

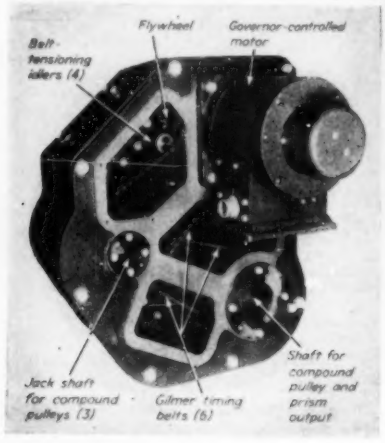
Panoramic Camera

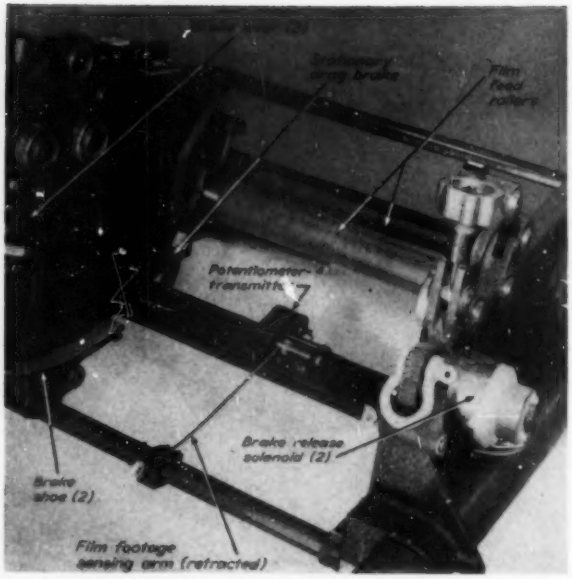
(*Continued*)

DRIFT COMPENSATOR controls oscillatory motion of focal plane to cancel out error due to forward motion of the plane. Amplitude of oscillation is varied remotely by position servo as function of ground speed and altitude.

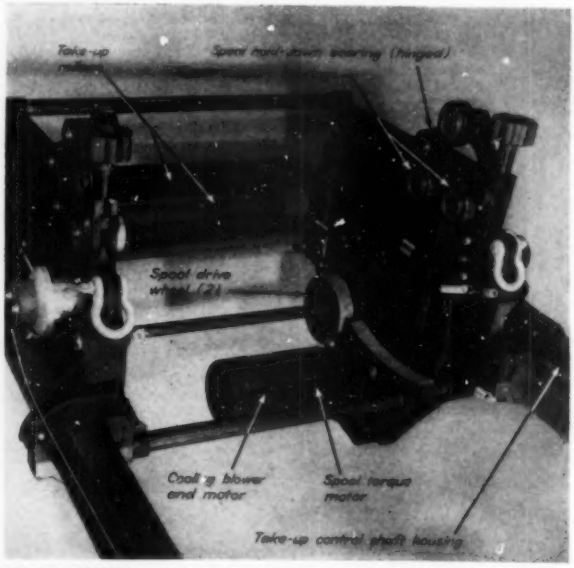


POWER UNIT contains two-speed, governor-controlled motor and belt transmission. Two-stage belt reduction drives flywheel and output shaft for scan rollers. Flywheel rotates prism through five stages of belts and drift compensating linkage through gears.





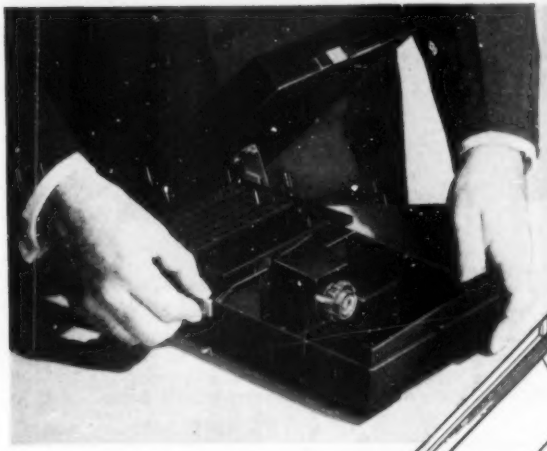
FILM IS PULLED OFF SPOOL BY feed rollers and piled up below ready to pass through camera. Sensing arm actuates potentiometer-transmitter unit which gives remote indication at panel of amount of film remaining on spool. Brakes are spring engaged and solenoid released. Stationary drag brake prevents spool from coasting after sufficient film for a single scan is pulled off spool.



SPOOL RIDES on two support bearings and is prevented from hopping out of this cradle by the hold-down bearing mounted in hinged arm. Torque motor turns take-up spool through two drive wheels that bear on the spool rims. Cooling blower and motor are integral with, though independent of, spool torque motor.

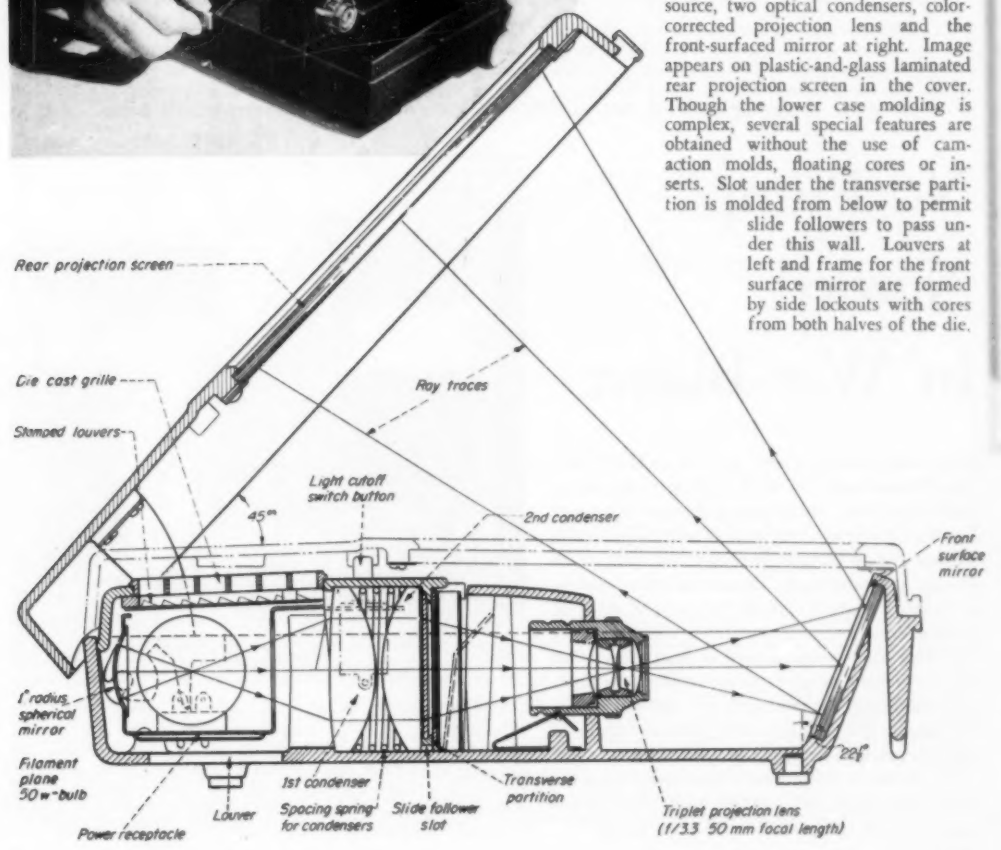
Complex Phenolic Case Easily Molded

By designing the four molded phenolic parts that make up the case and lens housing to perform several static and dynamic functions, the Port-A-View 35 mm slide projector requires only 18 fasteners in a total of 77 parts. Unit is easy to assemble, economical to fabricate, weighs only four pounds and measures 2¾ by 6¼ by 10½ in. Each of the two slide compartments holds 36 slides, each of which is magnified 4.8 times. Styling and engineering of the Port-A-View are the work of Lippincott & Margulies, Incorporated, and its manufacture is by the FR Corporation, also of New York.

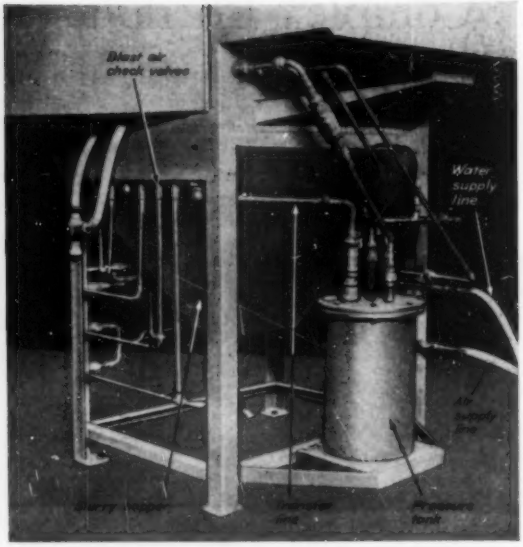


EACH SLIDE is pushed into position by the changer arm and ejected as the next slide slips into view. Flat springs, guides and integral cam projections such as the one at the front right corner of the grille housing insure proper functioning of the changer mechanism and prevent jamming should a slide be bent or warped. As the cover is raised, 50-watt ac-dc lamp under grille lights, just as in a refrigerator.

OPTICAL SYSTEM includes the spherical reflector at left, 50-w light source, two optical condensers, color-corrected projection lens and the front-surfaced mirror at right. Image appears on plastic-and-glass laminated rear projection screen in the cover. Though the lower case molding is complex, several special features are obtained without the use of cam-action molds, floating cores or inserts. Slot under the transverse partition is molded from below to permit slide followers to pass under this wall. Louvers at left and frame for the front surface mirror are formed by side lockouts with cores from both halves of the die.



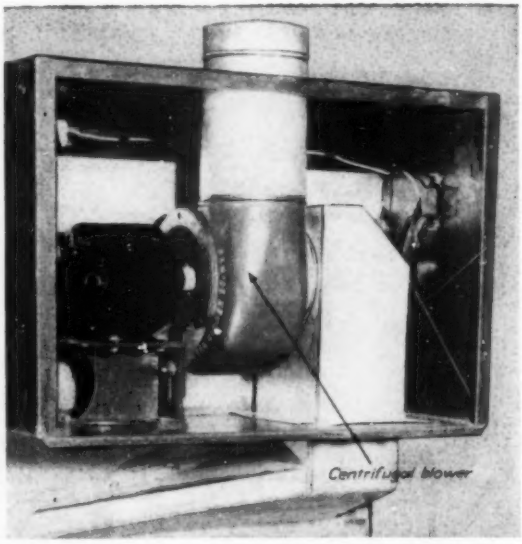
TWO LEVERS at knee level control main air blast and window wash-water valves. The 16½-by 23-in. side openings, one on each side, permit conversion of the unit to automatic line processing by routing a conveyor system through the cabinet of the blaster.



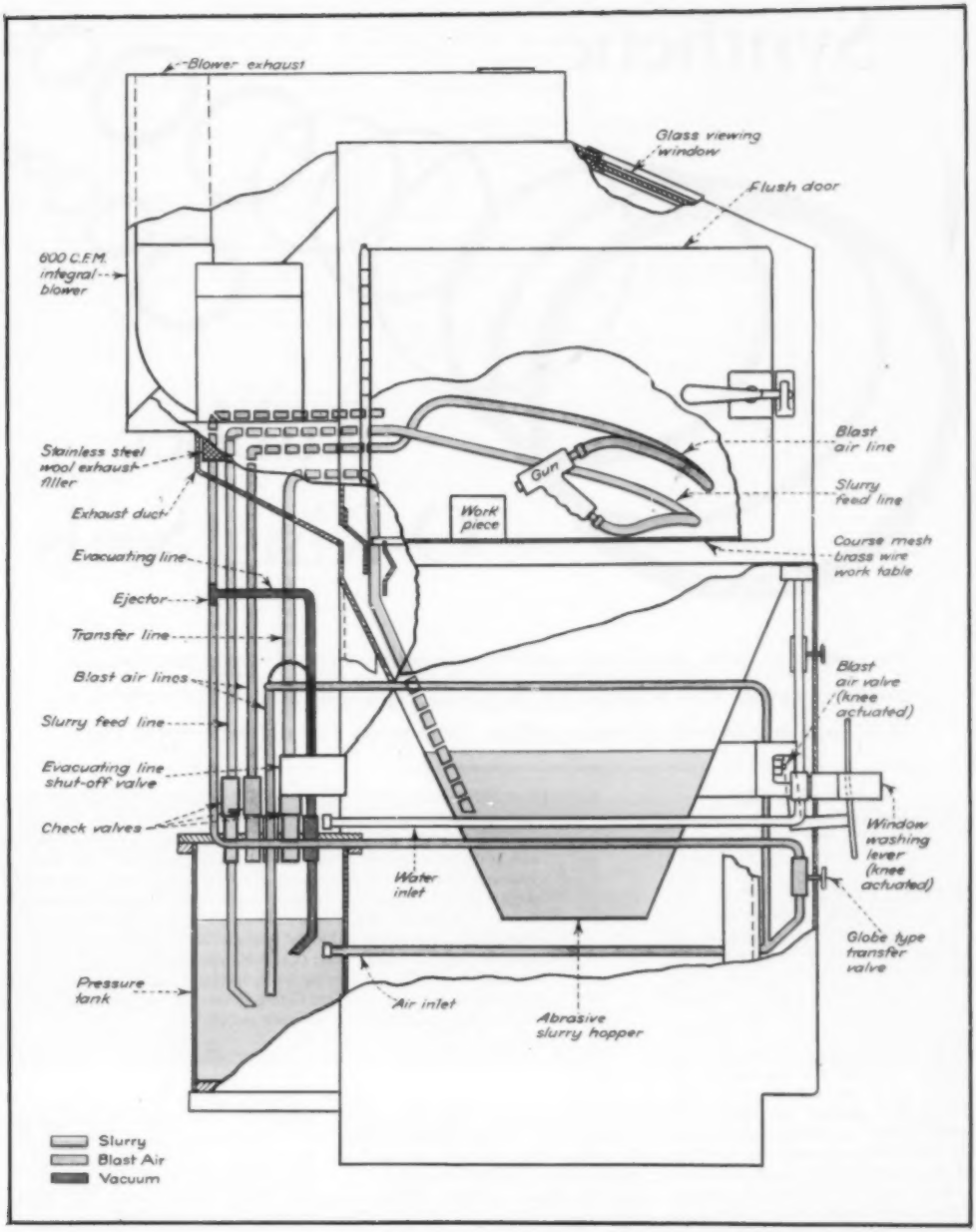
TRANSFER OF SLURRY from 35-gal hopper to pressure tank takes approximately 30 sec. Air requirements are those of standard shop equipment—60 cfm at 80 to 120 psi. Uniform surface finish on workpiece is obtained by controlling agitation of slurry to maintain a constant water-abrasive density.

No Pump Needed In Wet Blaster

No moving parts are used in the Cro-Hone pressure blaster made by the Cro-Plate Company of Hartford, Conn. By designing the unit to operate on shop air pressure supply of 80-120 psi and utilizing internal air pressure in conjunction with an air ejector and mixer-gun, abrasive mixtures can be accelerated to speeds greatly in excess of those of existing equipment. The result is a compact unit requiring about a square yard of floor space. No motors or circulating pumps are required for blasting; maintenance is practically nil, and cost is low. Because of the corrosive (and erosive) nature of the blast, abrasives ranging in size from 45 to 5,000 mesh can be used. All of the sheet metal parts are made from type 304 stainless steel, and all circulating lines are made from copper tubing.

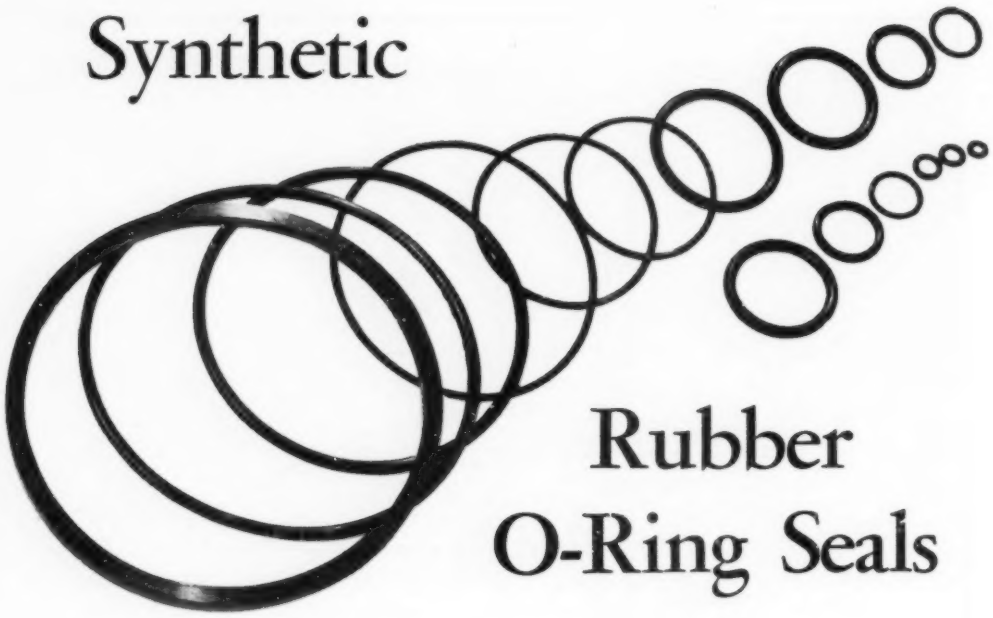


VAPORS above the 30- by 30-in. work table inside cabinet are exhausted through a filter at the top by a 600 cfm blower. Main function of the filter, which can be easily removed for cleaning, is to catch the particles of abrasive, yet at the same time pass a large volume of air. A light within the blast chamber, together with a viewing-window washer, eases inspection and manipulation of the workpiece during blasting.



TO ACTIVATE THE SYSTEM, the transfer valve is opened, admitting air to the evacuating line. As air passes through the ejector in this line, the pressure tank is evacuated, causing the air-agitated slurry to be syphoned from the hopper into the pressure tank. When tank is filled, main air blast valve is opened by knee-operated lever on front of cabinet. Blast air enters the tank to pressurize the slurry and then up to the gun. Two pressures are thus developed to propel the slurry from the tank and out the gun nozzle: First, the pressure head within the large-volume tank; and second, a slightly lower pressure at the gun. The differential between the two pressures causes the slurry to flow up into the gun where the air carries it out the nozzle as a jet. After the mixture leaves the gun and blasts the work piece, it is then collected in the abrasive slurry hopper.

Synthetic Rubber O-Ring Seals



For sealing of static or moving parts in hydraulic systems, O-rings have become widely accepted. This acceptance is increasing rapidly because of the availability of a large number of synthetic rubber compounds for different applications

E. L. CARLOTTA

Director of Rubber Research and Development
The Parker Appliance Company

O-RING OPERATION: At zero or very low pressure, the radial compression or diametral squeeze of the O-ring between the bottom of the retaining groove and the wall of the mating part effects the seal (A). If the O-ring were not so precompressed, the fluid would escape through the clearance between the mating parts and there would be no seal (B). As pressure is applied, the O-ring is forced to the opposite side of the groove, filling that space to give full sealing effect (C). Additional pressure simply forces the O-ring to distort further into the space, making a tighter seal. A change in direction of pressure moves the O-ring to the other side of the groove for sealing in either direction of pressure application.

MODERN HYDRAULIC SYSTEM REQUIREMENTS have increased the problems connected with sealing of an operating fluid. Such requirements are varied: For aircraft auxiliary equipment, high power, low bulk, accuracy of control and simplicity of operation are needed; in machine tools, a wide range of pressures and speeds, with accurate positioning and simple valves are needed; in the automotive field, greater use of hydraulic controls are increasing requirements for reliability and simplicity. In many of these installations, the loss of even a few drops of fluid in the pump, transmission piping, hydraulic motor or piston, cannot be disregarded.

There are many methods used to seal fluids in hydraulic systems; the most common devices include lip-type packings, flat gaskets, metal piston rings, and the like—all of which seal fluids adequately at pressures below 1500 psi. At higher pressures—up to 3000 psi, and higher in some of the newer systems—such seals are usually inadequate, or impose difficult design restrictions because of the heavier cross-sections that are necessary. For such conditions, synthetic rubber O-ring seals are usually satisfactory. The O-ring seal can be thought of as a rubber toroid that fits into a groove in a piston in such a manner that when the piston is inserted in the cylinder, the seal is slightly compressed between cylinder wall and the bottom of the seal groove.

Synthetic rubber O-rings can be compounded and molded to meet the following operating requirements:

1. Molded to close dimensional tolerances, so they can operate under a controlled amount of squeeze.

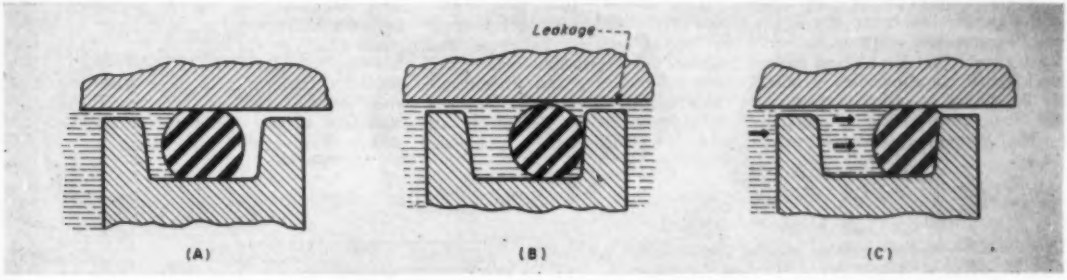
2. Compatibility with the fluids handled. Excessive swell may so increase the size of the O-ring that it is extruded into the clearance between the piston and the cylinder, where the extruded portion can be easily broken off. Shrinkage of the ring should also be avoided, since this would reduce the squeeze necessary to seal, and probably result in leakage.

3. Withstand working hydraulic

Table I—Properties of O-Ring Materials

Compound No. and Type of Rubber Base	Service	Temperature Range, F	Hardness Shore A*
PS-1-30-5, Buna N	AN-VVO-366B hydraulic fluid (aircraft).	−65 to +180	70±3
PS-20-5, Buna N	Hydraulic oil, SAE 10, 20 and 30. General hydraulic services.	−60 to +150	70±5
PS-10-13 Rev. B, Buna N	40% aromatic fuels and aviation gasoline (65 and 100 octane).	−65 to +160	55±5
PS-10-13 Rev. K, Buna N	Special compound, having low hysteresis, suitable for all rubber diaphragms for use in aviation gasolines.	−65 to +180	65±5
PS-10-13 L, Buna N	Aromatic and non-aromatic fuels, for static and moving seals.	−65 to +180	65±5
PS-10-13 N, Buna N	Aromatic (30% max) and iso-octane aviation fuels.	−70 to +160	55±5
145-140, Buna N	O-ring seal for fluid type fittings in AN6290 series O-rings.	−65 to +180	90±5
147-56, Thiokol	Aromatic and non-aromatic oil and hydraulic fluid, and solvents.	−65 to +160	65±5
PS-40-5, Natural Rubber	Automobile hydraulic brake fluid. (Lockheed 21).	−40 to +212	70±5
372-23, Butyl Rubber	Dilute acids and alkali.	−40 to +215	65±5
216-2, Buna N	Water and water pump anti-freeze	−40 to +200	65±5
435-2, Buna N	High temperature compound for oil service.	−40 to +300	65±5
448-10, Buna N	Freon gas (F-12 and F-22) butane and propane gas.	−40 to +250	80±5
187-4B, Buna N	Rubber-graphite seal.	−40 to +225	70±5
187-4C, Buna N	Steam and water.	−40 to +325	70±5
360-1 Rev. A, Buna N	Diesel fuels.	−40 to +212	65±5
248-9, Buna N	Sanitary services, odorless and tasteless. (Compound is black).	−40 to +275	70±5
578-1, Neoprene	Hydraulic oil, SAE 10, 20 or 30. General hydraulic service.	−85 to +275	60±5

*Durometer reading (Shore A) of 35 is considered soft; 90 is considered hard.



pressures without leakage. Hydraulic pressures up to 1500 psi are normally used for most commercial applications and pressures up to 3000 psi have been used for some aircraft systems, provided the sealing ring is protected with a suitable leather backup ring or anti-extrusion device. Resistance of the O-ring to deformation under pressure is usually associated with the Shore durometer "A" hardness.

4. Seal at sub-zero as well as higher than normal room temperatures. Special compounds are available which operate over an extreme range, from minus 85 to plus 275 F, satisfactorily without leakage.

5. Low friction, particularly low "break-out" (starting) friction.

6. Sufficient torsional strength and elongation to avoid twisting type failures and sufficient wear resistance to withstand abrasion by metal components of the hydraulic system. These properties can be maintained over long periods of time. The tensile strength and elongation of an O-ring are of prime importance since the ring is stretched during installation.

Of course, actual requirements vary with the specific application. As shown in Table I, a number of compounds are commercially available for hydraulic sealing. However, for special conditions, an almost limitless variety of materials can be "tailor-made" from the following basic elastomers (rubber polymers):

Crude (Natural) Rubber—Petroleum oil is a natural enemy of crude rubber compound, causing it to swell and soften. Castor and other vegetable oils cause only moderate swelling, while glycerin, ethylene glycol, and plain water cause negligible vol-

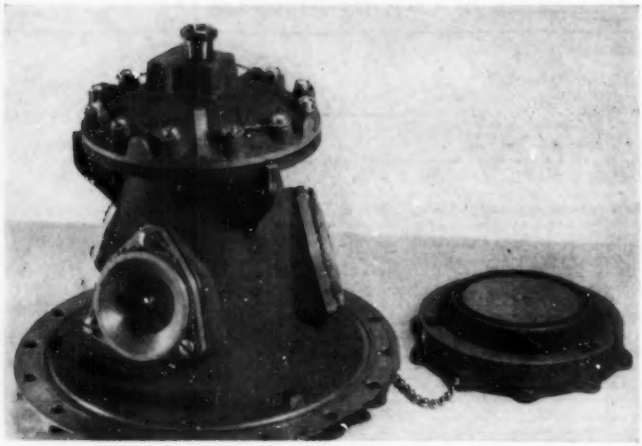


Fig. 1—O-ring seals molded of nitrile-type synthetic rubber meet in this tank-mounted nozzle receiver for high-speed, closed system pressure fueling and defueling of aircraft.

ume increase. Natural rubber, however, swells excessively in turpentine, carbon bisulfide, chloroform, benzene, naphtha, and carbon tetrachloride.

Vulcanized compounds can be made to resist moderate concentrations of most inorganic acids, alkalies, and inorganic salts. These are good electrical insulators, with dielectric strength ranging from 100 to as high as 550 volts per 0.001 in. of thickness. Crude or natural rubber compounds that conduct electricity are now being used.

Ordinary natural rubber compounds will withstand heat up to 200 F, but special compounds can resist temperatures around 300 F. Natural rubber stocks are extremely flexible at minus 65 F, and can be compounded to resist temperatures as low as —300 F.

Butyl Rubber—This is an all petroleum product made by co-polymerizing isobutylene and just enough isoprene to permit vulcanization. Butadiene can be used in place of isoprene. Butyl rubber shows excellent resistance to vegetable oils, lard, and dilute organic acids and alkalies. Its high resistance to gas permeation accounts for many of its applications, such as gas masks and inner tubes. Operating temperatures range from minus 65 to plus 300 F for butyl rubber compounds.

GR-S Rubber—This "general purpose" type synthetic rubber is made by co-polymerizing butadiene and styrene. GR-S resembles crude rubber, both in processing and performance characteristics. It is not oil resistant.

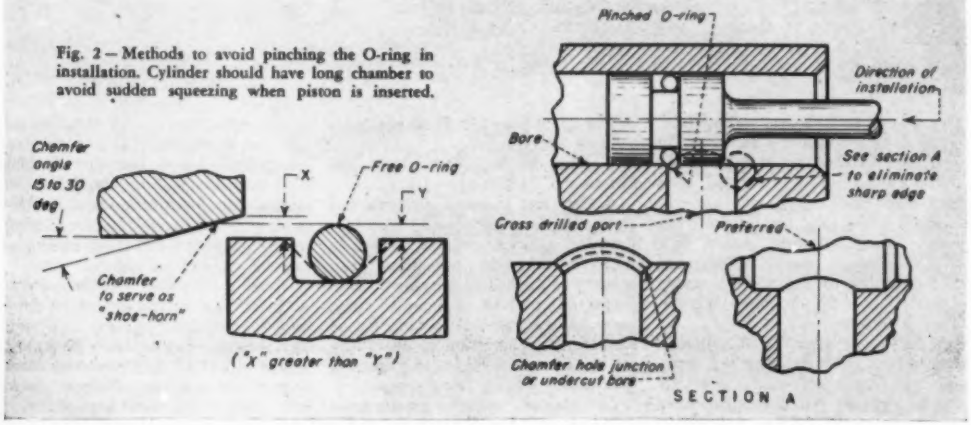
Neoprene Rubber—Neoprenes are made by polymerizing chloroprene (chlorobutadiene). They possess excellent resistance to ozone, good resistance to oils, sunlight, heat, and aging. Good mechanical properties are features of this family. The neoprenes are used for oil hose, gaskets, belts, wire insulation, vibration insulators, and other applications where oil is likely to be encountered. Neoprene stocks can be compounded to resist temperatures from minus 85 to plus 275 F.

Nitrile Rubber (Buna N)—A type of American rubber made by co-polymerizing butadiene and acrylonitrile. Outstanding characteristic is resistance to oils and other solvents. Products in which it is used include oil, fuel, and hydraulic equipment parts. Buna N compounds usually have excellent resistance to high temperatures (325 F max), aromatic fuels such as aviation gasoline (Fig. 1); and superior tear, sunlight and ozone resistance. They can be formulated to operate at temperatures of minus 75 F or lower.

Silicone Rubber—The silicones are a group of plastic materials made from silicon oxygen, hydrogen, and carbon. In the rubbery form, the plastic has poor mechanical properties, but possesses extraordinary heat resistance and is therefore useful in gaskets, seals, and for other applications where elevated temperatures are encountered (maximum 525 F). Silicone rubber is also used for extreme low temperatures, seals for aircraft hydraulics and for use in liquid oxygen at temperatures on the order of minus 110 F.

Polysulfide Rubbers (Thiokol)—Rubber characteristics of these materials develop with an increase of molecular weight. These polysulfide rubbers have excellent resistance to

Fig. 2—Methods to avoid pinching the O-ring in installation. Cylinder should have long chamber to avoid sudden squeezing when piston is inserted.



oils and solvents including carbon tetrachloride and acetone. They withstand low temperatures (to —65 F), ozone, and sunlight, but have low heat resistance (maximum 160 F), and their tensile strength does not approach the maximum of Buna N rubber and similar materials. Applications include the making of seals and gaskets for fuel, oil, and hydraulics for aircraft specialities, hose for oil solvents, linings for gasoline and chemical tanks, and similar uses.

Design and Installation

O-ring gland requirements vary somewhat according to different sealing applications. For instance, for a static or non-moving seal under low pressure, the requirements may not be so exacting as for a high pressure dynamic or moving seal. However, the following requirements are generally applicable:

SMOOTH SURFACES. O-rings should never be installed over sharp corners, threads or slots, as cuts or nicks in the O-ring can cause leakage. Corners of the O-ring groove should be chamfered. Clearance between the piston and cylinder should be held as close as production methods will allow. Surface finish of the cylinder bore and piston rod should be as smooth as possible to aid assembly of the O-ring, and the cylinder should have a long chamfer so the O-ring can be squeezed gradually when the piston is inserted. Fig. 2 shows methods to avoid pinching the O-ring in installation. For operating pressures in excess of 1500 psi, the use of back-up rings of leather, Teflon, Kel-F or other suitable material, may be necessary to prevent excessive extrusion of the O-ring seal into the clearance space.

Table II—Bore and Groove Dimensions for Proper Seal Pressure

O-Ring Nominal Cross Section Dia, in.	O-Ring Actual Cross Section Dia, in.	Percent Stretch to ID of O-Ring	Min. Cross Section Dia Squeeze, in.
1/16	0.070±0.003	2 to 4.5	0.010
3/32	0.103±0.003	3.5 to 6.0	0.010
1/8	0.139±0.004	3.5 to 6.5	0.012
3/16	0.210±0.005	3.5 to 7.0	0.017
1/4	0.275±0.006	3.5 to 7.5	0.027
over 1/4	Actual	3.5 to 7.5	0.028

Example:
Seal Dimensions: 1.234 ID × 0.139 cross-section
Groove Diameter = ID of O-ring plus 5 percent of O-ring ID
1.234 + (1.234 × .05) = 1.296 in.
Bore Diameter = Groove diameter plus twice cross-section diameter of ring minus twice minimum cross-sectional squeeze
1.295 + (2 × 0.139) − 2 (0.10 × 0.139) = 1.546 in.
Groove Width = O-ring cross-section dia plus 10 percent of cross-section dia
0.139 + (0.10 × 0.139) = 0.1529 in.

GROOVE SHAPE. In most applications, the rectangular groove shape (Fig. 3) is preferred. The groove should be long enough to provide adequate volume for the O-ring cross section in the squeezed condition and volumetric swell of the O-ring due to fluid immersion, as well as for easy removal and replacement of the ring. However, particularly in static or non-moving seals, other groove arrangements may be used if necessary because of space limitations or construction features (see pages 134 and 135).

CLEARANCE. Particularly for moving seals, clearance between adjoining metal surfaces at the gland should be held as close as possible within the necessary allowance for thermal expansion differential of the metals over the operating temperature range. If the clearance is too great, there will be excessive extrusion of the O-ring into this gap which might cause the ring to break down and fail. For easier machining, and to aid assembly, the groove should be located on the rod whenever possible, rather than in the cylinder wall.

GLAND FINISH. For maximum life of the O-ring, polished chrome or nickel plated hardened steel piston rods and honed steel or cast iron cylinder bores should be used. For moving seals, the surface finish should be as smooth as possible. A micro inch finish of 20 RMS or less is recommended for pressures over 500 psi. Longitudinal scratches should be avoided since they cause repetitive wear in the same spot. The best finish for minimum friction is produced by honing (providing codirectional marking) good hardened steel, then hard nickel plating and polishing it. Also, a burnished finish is suitable. Roller burnishing produces a satisfactory surface and pump barrel finish steel tubing has been used successfully.

LUBRICATION. Normally, the oil or other fluids in the system supply sufficient lubrication to minimize O-ring friction in a moving seal. However, in pneumatic or dry operated systems, O-rings wear rapidly unless lubrication is provided. For this purpose, use of a pneumatic system grease in the groove is recommended. Felt rings or leather back-up rings, saturated in a good grade of lubricating oil, and installed in separate grooves on both sides of the O-ring, are satisfactory.

DIMENSIONS. For cylinders 6 in. in diameter or less, an O-ring of $\frac{1}{8}$ in nominal cross section is suggested. For cylinders more than 6 in. in diameter, an O-ring with a nominal cross section diameter of $\frac{3}{16}$ in., $\frac{1}{4}$ in. or more should be used, depending on space and operating conditions suitable for such packing. Table II shows recommended dimensions.

(*continued on next page*)

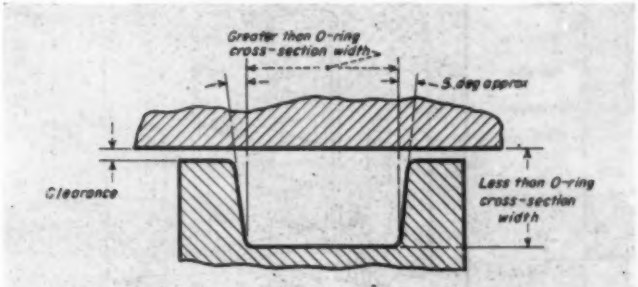
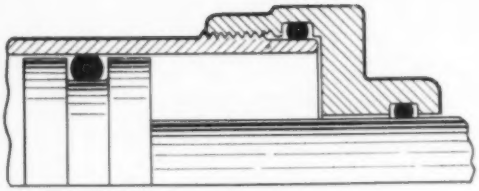


Fig. 3—Rectangular groove standardized for moving seals. Depth of the groove plus the clearance between the mating metal parts constitutes the gland width. The gland width must be less than the O-ring cross-section width to provide sufficient squeeze of the O-ring for a seal at zero or very low pressure. Groove width is greater than the O-ring cross-section width to provide for the distortion caused by the diametral squeeze—and to facilitate installation and replacement.

O-Rings Perform Satisfactorily in

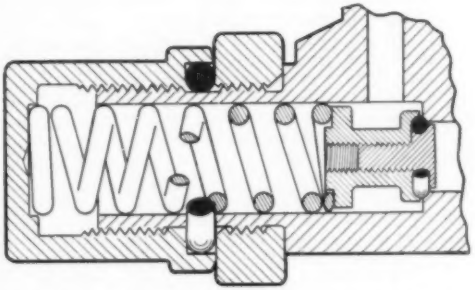
MOVING SEALS—Running friction of the O-ring is an important factor. This factor is influenced by degree of diametral squeeze of the O-ring, oiliness of the fluid, hardness of the compound, length of the rubbing surface, finish of the metal parts, and finally the hydraulic pressure.

Poor film-forming fluids may subject the sliding O-ring to abrasion and overheating, particularly in continuously and rapidly reciprocating action. On rotating or oscillating shafts, O-rings serve satisfactorily if the rubbing speed is not high. For this kind of motion, the length of the groove can be reduced to help prevent bunching of the O-ring.

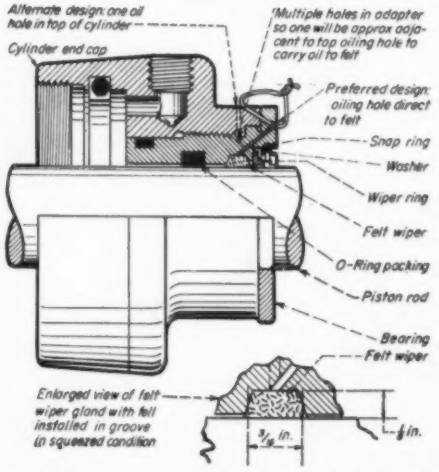


TYPICAL O-RING APPLICATIONS in a hydraulic cylinder. The O-rings sealing the piston and the piston rod are subject to sliding movement, the O-ring in the cap piece is a static seal. Use of two rings on the piston may cause a pressure or vacuum trap.

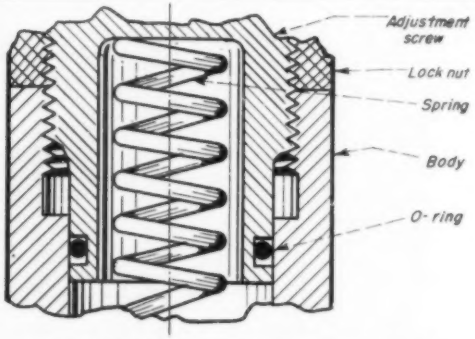
NON-MOVING OR STATIC SEALS—O-rings provide leakproof sealing in a wide variety of non-moving gasket applications. Since friction is not a factor the O-ring can be compressed safely to a greater degree than in moving seals. In some static seal applications, O-rings can hold extremely high pressures, even under severe vibration and repeated surge conditions, and despite slightly irregular sealing surfaces. Greater latitude is permissible in groove design for static seals.



RELIEF VALVE shows use of an O-ring as a spring-loaded adjustment cap seal and employment of a second O-ring in the brass piston to provide a rubber-to-metal seat for holding air or gases with no leakage. For protection the seal is partially enclosed by the assembly.

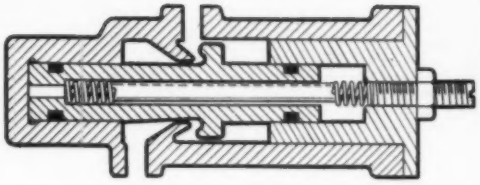

Alternate design: one oil hole in top of cylinder
Cylinder end cap
Multiple holes in adapter so one will be approx adjacent to top oiling hole to carry oil to felt
Preferred design: oiling hole direct to felt
Snap ring
Washer
Wiper ring
Felt wiper
O-Ring packing
Piston rod
Bearing
Felt wiper
Enlarged view of felt wiper gland with felt installed in groove in squeezed condition
3/8 in.
1/4 in.

IN HYDRAULIC UNITS, the hydraulic fluid normally provides sufficient lubrication. However, in some applications, lubrication as augmented by usage of the felt wiper may be desirable. As indicated, means of relubricating felt rings should be provided.

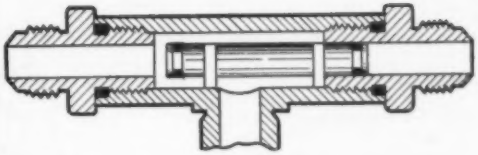


USE OF AN O-RING as an adjustment screw seal. The end of the screw with the O-ring groove is smaller in diameter than the threaded section so that, when inserting the screw, the outer surface of the O-ring is not forced to contact the internal threads.

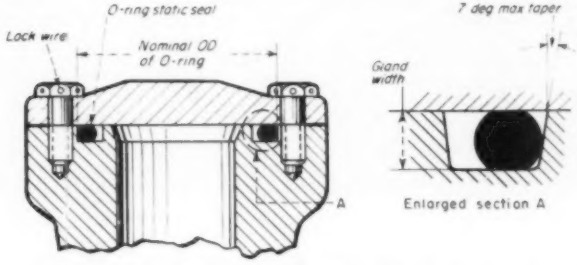
Dynamic and Static Seal Applications



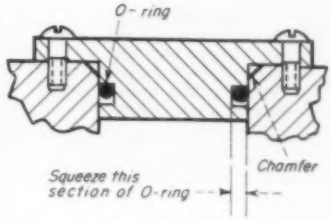
FLOW CONTROL VALVE with O-ring sealing at both ends of the moving plunger. The O-rings are subject to sliding movement. The original diametral squeeze of the O-ring effects the initial seal and fluid pressure tends to "push" the O-ring into any leakage clearance; the greater the pressure, the tighter the seal.



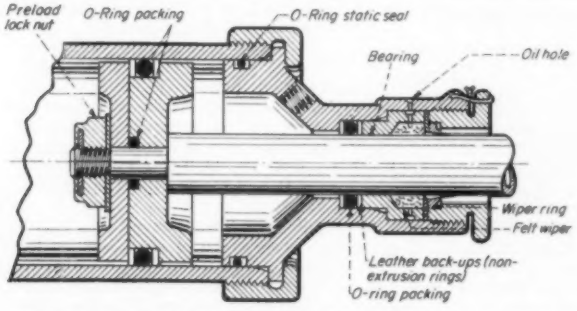
HYDRAULIC SHUTTLE VALVE with O-rings as moving seals on each end of the plunger and with O-rings as static seals at the threaded fitting connections. As the shuttle operates, one O-ring on the moving plunger becomes "free" but becomes a seal when the shuttle reverses. An O-ring unrestrained at various stages of operation of the unit sometimes swells in certain liquids.



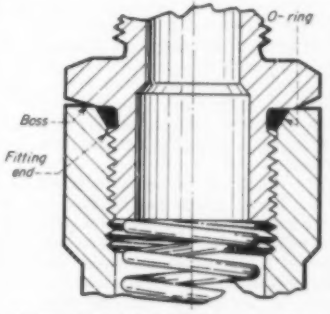
SUGGESTED FACE SEAL O-RING APPLICATION. In this case, the rectangular shape groove is employed. The gland width should be less than the O-ring cross section width to provide compression or diametral squeeze of the O-ring. The nominal outside diameter of the O-ring indicates the outside diameter of the circular groove as machined in the metal part to which the end cap is bolted.



HOLE PLUG SEAL, with the O-ring contained in the groove in the plug, being squeezed between the bottom of the groove and the wall of the holed part. The corner of the hole entrance should be chamfered to prevent pinching and damaging of the O-ring in installation.



USE OF LEATHER BACK-UPS or non-extrusion rings with synthetic rubber O-rings for effective running seals under high pressures (1500 to 3000 psi). The back-ups prevent excessive extrusion of the O-ring into clearance gaps between piston and cylinder wall and between piston rod and its housing. O-rings are also shown without back-ups in two static seal applications. Note O-ring in piston assembly for sealing at a three-part junction.

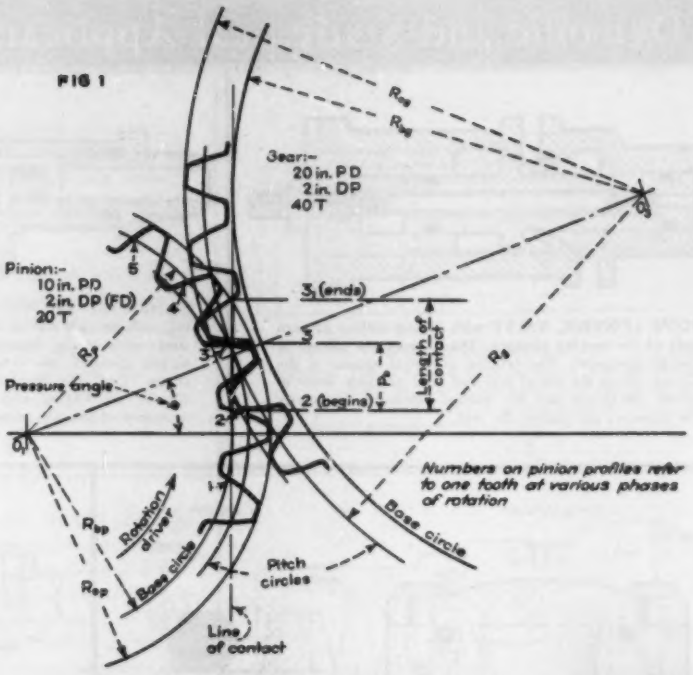


IN THIS NON-MOVING APPLICATION, showing a valve end connection, the O-ring is contained in an irregular shape cavity, which, of course, must bear the proper relationship to the volume of the O-ring.

Fig. 1—The beginning and the end of engagement of teeth in a meshing pinion and gear.

Fig. 2—Simplified layout for study of tooth contact. (A) Center distance is drawn to a small scale, and a projection ray locates the lower extremity of the contact length on the large scale layout. (B) Contact diagram gives length of gear face engaged for one pair and two pair contact.

Fig. 3 — Three typical examples showing the uses of the contact layout. (A) For checking teeth in contact. (B) For finding contact angles. (C) For finding contact ratio.



Tooth Contact Layouts for

HAROLD M. DURHAM

TO STUDY GRAPHICALLY the amount of tooth contact obtained in a rotating pair of involute spur gears, it is usual to prepare a layout similar to Fig. 1, and from it determine the pairs of teeth in mesh simultaneously over the length of contact as the gears are rotated.

The length of contact is indicated by the heavy vertical line in Fig. 1; it is a segment of the common tangent of the base circles. The length of this segment is the distance between the intersections of the outside diameter circles of the pinion and the gear, that is, where tooth engagement begins and ends as at points 2 and 3_1 respectively. Although the numbers on the profiles in Fig. 1 indicate different teeth, these numbers may also indicate relatively rotated positions of the same tooth.

Data that are relevant to the construction of Fig. 1 are:

φ = pressure angle, deg
P = diametral pitch
p = circular pitch, in. = π/P
p_b = base circle pitch, in. = $p \cos \varphi$
n = number of teeth in pinion
N = number of teeth in gear
R_p = pitch radius of pinion, in. = $n/2P$
R_g = pitch radius of gear, in. = $N/2P$
R_{bp} = base circle radius of pinion, in. = $R_p \cos \varphi$
R_{bg} = base circle radius of gear, in. = $R_g \cos \varphi$
a = addendum, in.
R_{op} = outside radius of pinion, in. = $R_p + a$
R_{og} = outside radius of gear, in. = $R_g + a$
C = center distance, in. = $R_p + R_g$

Length of contact

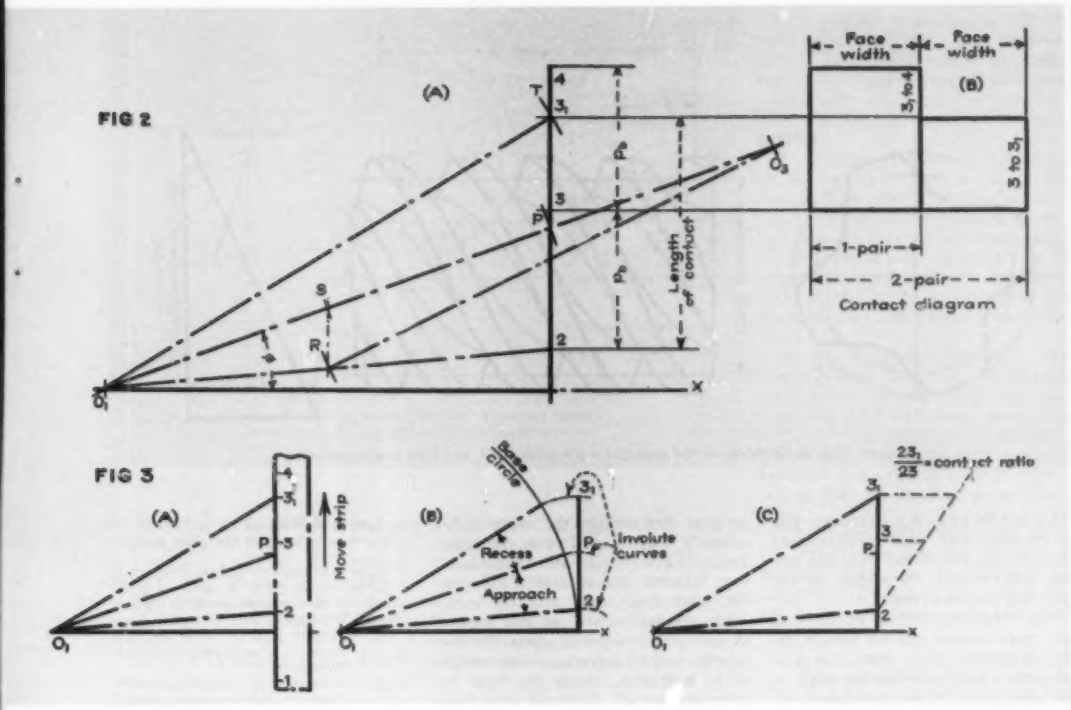
$$= \sqrt{R_{op}^2 - R_{bp}^2} + \sqrt{R_{og}^2 - R_{bg}^2} - C \sin \varphi$$

In attempting to study Fig. 1, one soon becomes aware of the difficulties that arise in identifying positions of the teeth after rotation. Another difficulty with drawings that use a reduced scale, so as to include the centers of the gears, is that only a small line segment is available for study.

With the objective of avoiding the foregoing difficulties, a simplified layout is proposed. This layout, which may be called a "contact layout," shows only a minimum number of necessary lines and points.

Referring to Fig. 2 (A) the construction of the simplified layout is as follows:

1. Draw horizontal line O_1X.
2. Through O_1 draw a line at the angle ϕ from O_1X.
3. To any convenient scale
   a. Lay off O_1O_3 equal to the center distance.
   b. Lay off the arc R using a radius O_3R equal to the outside radius of the gear.
   c. Lay off the arc S using a radius O_1S equal to the pitch radius of the pinion.



Spur and Helical Gears

Simplified method for the construction of layouts used in making graphical studies and investigations of the tooth contact obtained in meshing pairs of involute spur gears and of helical gears. Chart is included giving the percentage of overlap obtained with different values of face width, nominal pitch, and nominal helix angle.

d. From the intersection of arc S with line O_1O_3, drop a first vertical line to intersect arc R.

4. To as large a scale as possible

e. Using a radius O_1P, equal to the radius of the pinion, locate the pitch point P on line O_1O_3.

f. Lay off arc T using radius O_1T equal to outside radius of pinion.

g. Draw a second vertical through P to intersect horizontal line O_1X and arc T, thus locating point 3_1.

h. Through O_1 and the intersection of the first vertical with arc R, draw a ray to intersect the second vertical, thus locating point 2.

i. From point 2 lay off several base pitches on the second vertical.

A word of caution is necessary in regard to the intersection of the arc R with the vertical line from the intersection of arc S and the line of centers. It is important that these intersections be accurately located, since in projecting to point 2 any error is multiplied.

The "Contact Diagram," Fig. 2 (B), gives the total length of gear face engaged for one pair contact and two pair contact. The offset shows single pair engagement.

The uses of the contact layout, Fig. 2 (A) are given in the examples shown in Fig. 3. A simple method is shown in Fig. 3 (A) for determining the numbers of pairs of teeth in contact at any instant.

Where it is desired to know the angle of action and its components, that is, approach and recess angles, Fig. 3(B) is helpful. Fig. 3(B) applies to the pinion.

The contact ratio is given without calculation by the construction shown in Fig. 3(C). This ratio is numerically equal to the length of contact divided by the base circle pitch. The value of this ratio indicated in Fig.

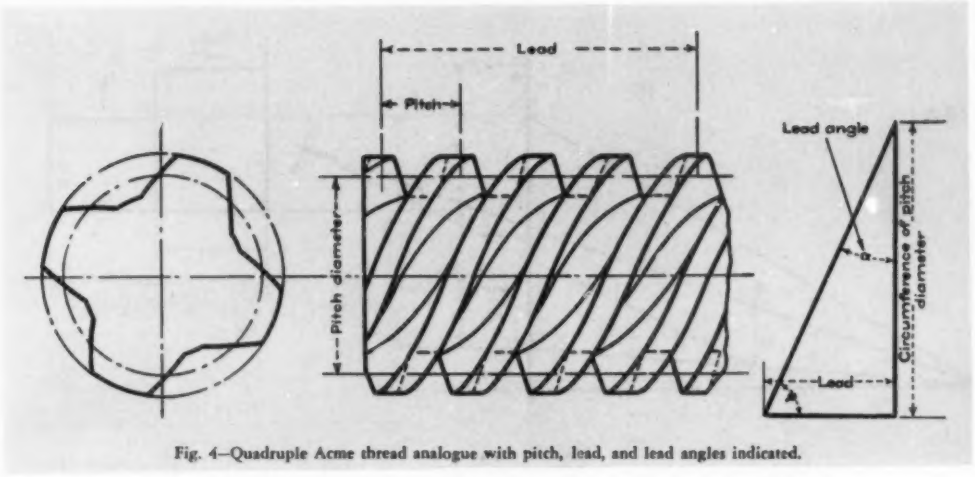


Fig. 4—Quadruple Acme thread analogue with pitch, lead, and lead angles indicated.

3(C) is 1.64 to 1. For one tooth cycle of rotation, this ratio is interpreted thus: 64 percent of the cycle has two pair contact, and 36 percent of the cycle has one pair contact.

The foregoing method of studying spur gear contact can be readily extended to study tooth contact in helical gears. To clarify the approach to the application of the simplified diagrams to helical gears, use will be made of the screw thread analogy.

A quadruple Acme thread is shown in Fig. 4 with terms such as pitch, lead, and lead angles indicated.

While the working diameter of a thread is usually the outside diameter, there are also pitch and root diameters as in gears. By an unfortunate usage of terms, the helix angle of a thread is that indicated by α in Fig. 4, while in gear terminology the angle indicated by Ψ is referred to as the helix angle. These angles are complementary, however, and to avoid confusion the term lead angle may be used. There are any number of lead angles. A lead angle depends upon the diameter, or circumference, with which it is associated. Since the lead is constant for all diameters, the lead angle changes with a change in diameter or circumference.

Two adjacent tooth elements of a single helical pinion are shown in Fig. 5. The teeth have all the characteristics of screw threads except that the tooth profiles are involute curves in all planes normal to the axis of rotation. Where

A_l = axial lead, in.
N = number of teeth
A_p = axial pitch, in.
ψ = helix angle at the pitch surface, deg
ψ_b = helix angle at the base surface, deg
p = circular pitch of teeth on pitch circle in a plane normal to the axis of rotation, in.
p_b = circular pitch of teeth on base circle in a plane normal to the axis of rotation, in.
p_o = circular pitch of teeth on outside diameter circle in a plane normal to the axis of rotation, in.
R = pitch radi s, in.
R_b = base circle radius, in.
R_o = outside radius, in.

for helical gears the following relations apply

$$R = p\,N/2\pi$$
$$A_l = A_p N = 2\pi R \cot \psi$$
$$A_p = A_l/N = 2\pi R \cot \psi / N$$

The characteristic property of "wrapping" around the pinion inher-

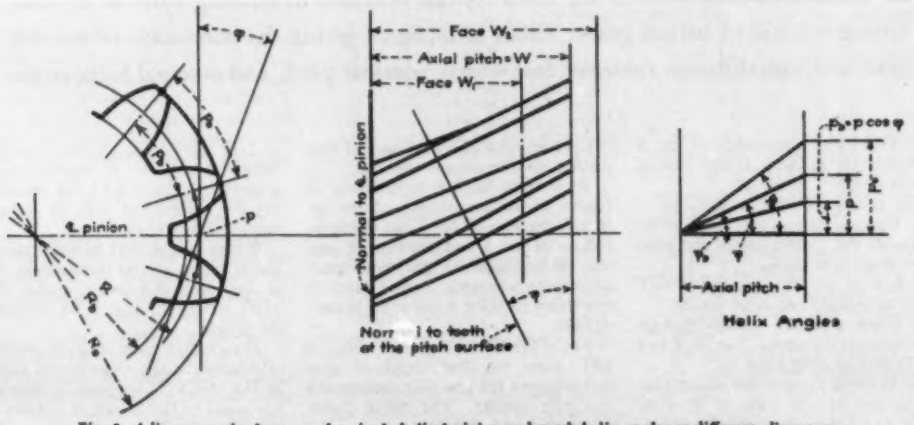


Fig. 5—Adjacent tooth elements of a single helical pinion and tooth helix angles at different diameters.

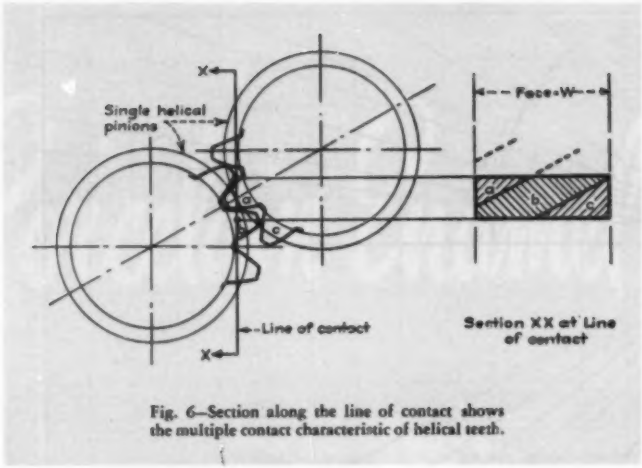


Fig. 6—Section along the line of contact shows the multiple contact characteristic of helical teeth.

ent in helical teeth, as shown in Fig. 5, gives rise to a new aspect when their contact is studied. In applying the spur gear technique exemplified in Fig. 2 to helical gears, an additional diagram or "Zone of Contact" is needed.

In Fig. 6 is shown a section *XX* taken at the line of contact of a pair of helical gears. The contact lines are along diagonals and indicate a multiplicity of teeth in action. Thus it is necessary to include the base helix angle as well as the face width in the study of tooth contact.

To make a series of sections such as Fig. 6 entails much time. The investigation can be simplified by reverting to the spur gear method with the help of a rectangular area (contact zone) having a width equal to the face of the gear and a height equal to the length of contact, Fig. 7(A). Across this zone is moved a strip of transparent paper upon which is drawn a series of parallel lines inclined at the base helix angle, the vertical distance between the parallel lines being equal to the base circular pitch. By adding the length of the contact lines and portions of these lines included in the rectangular contact zone, the Fig. 7(B) is constructed.

The saw tooth line on the right hand side of Fig. 7(B) is caused by the face width being less than the axial pitch. When the face width is equal to the axial pitch, the contact diagram is a true rectangle. Similar results can be obtained by changing either the pitch or the helix angle so that the trailing edge of one tooth is directly opposite to the leading edge of the adjacent tooth. A resultant straight line for the sum of the diagonal contact lines defines the minimum requirement for good tooth action. This condition is described as "zero overlap."

To compare the effect of face width on the contact diagram, for the same circular pitch and helix angle, in Fig. 7(C) are shown superimposed contact diagrams for the three face widths, W, W_1 and W_2 indicated in Fig. 5. In general, it is desirable to investigate each individual design to determine the optimum curve on the contact diagram.

In the foregoing discussion, the diagrams used have made use of base circle pitch and base helix angle, because the zone of contact is figuratively unwound from a base cylinder. For a study of single tooth overlap, however, it is possible to avoid calculations that use the base plane functions.

It is shown in Fig. 8, that the overlap depends on the face width and the axial pitch and is equal to their difference. The axial pitch, obviously, can be calculated either from the base

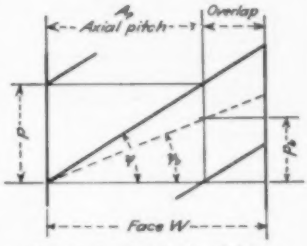


Fig. 8—Overlap is the difference between face width and axial pitch.

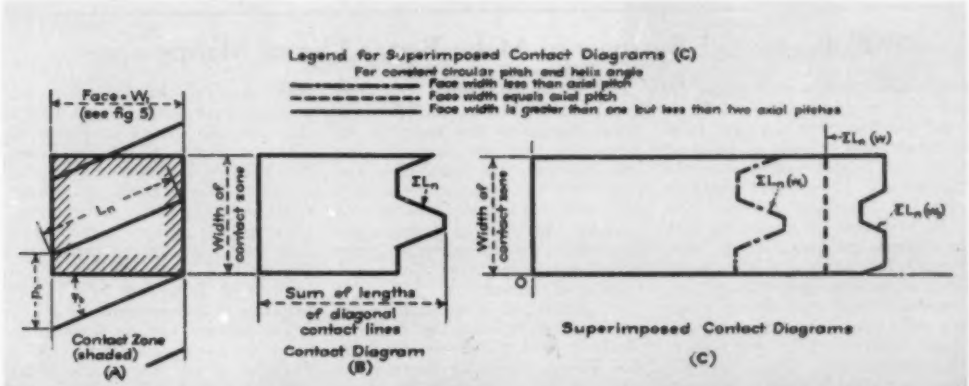


Fig. 7—(A) and (B) Contact zone and contact diagram with saw tooth curve of tooth engagement. (C) Super-imposed contact diagrams for three face widths when circular pitch and helix angle are constant.

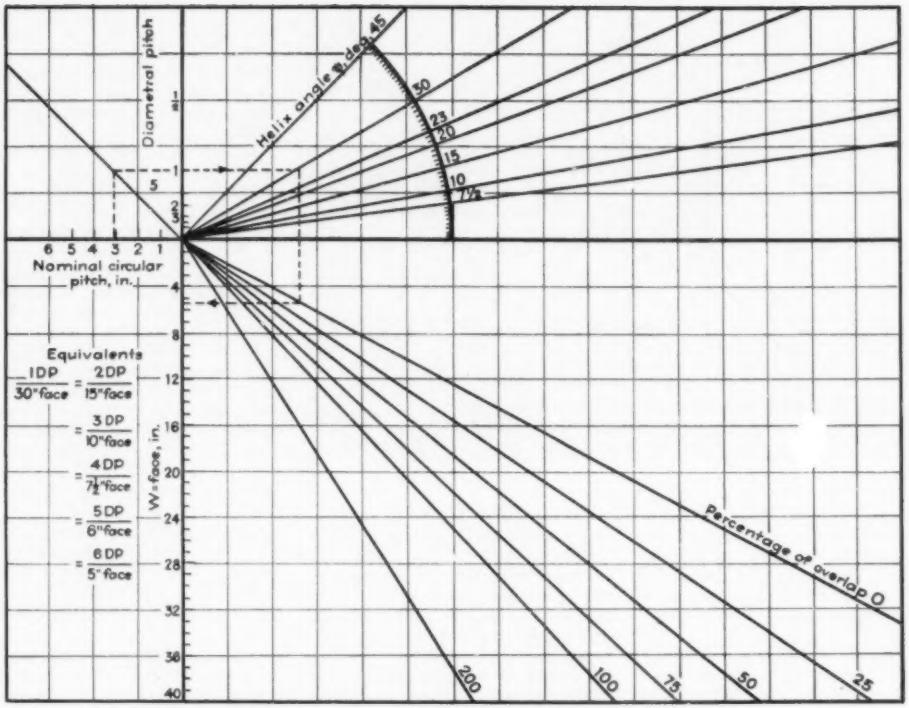


Fig. 9—Percentage of overlap obtained with different combinatons of nominal circular pitch, diametral pitch, face width, and helix angle at the pitch surface.

circle or pitch circle, whichever is most convenient, by using the values of helix angle and circular pitch at the respective circles.

The percentage Z of overlap can be calculated as

$$Z = 100\,(W - A_p)/A_p$$
$$= 100\,(W/A_p) - 100$$

and since

$$A_p = p \cot \psi = p_b \cot \psi_b$$
$$Z = 100\,(W/p \cot \psi) - 100$$
$$= 100\,(W/p_b \cot \psi_b) - 100$$

The chart in Fig. 9 gives the percentage of overlap obtained with different combinations of nominal circular pitch p, diametral pitch, helix angle Ψ at the pitch surface, and face width W. For a given pitch and face width, values of helix angle can be read off the chart to satisfy any desired percentage of overlap. Inversely when helix angle and overlap are specified, appropriate values of pitch and face width can also be read off the chart.

Colleges Aid Business to Make Better Use of Manpower

EVENING COURSES to train people for new jobs or bigger jobs in order to offset the manpower shortages faced by industry and business are being set up by each member institution of the Association of University Evening Colleges, 17 Lexington Avenue, New York, New York, in cooperation with the business companies of its community. The subjects of the courses are those concerned with management, supervision, sales and services auxiliary to management but not with trades, crafts, machine operation or other manual skills. Thus, the objective is to develop individuals who will aid fewer people to produce and distribute more goods.

Located in the chief urban centers close to industrial plants and commercial establishments, the 76 educational institutions that make up the Association have the necessary space and experienced administrative personnel but will draw instructors on a part time basis from industry and business. Any training program that is developed by any college or group of colleges in the Association is offered to all the members.

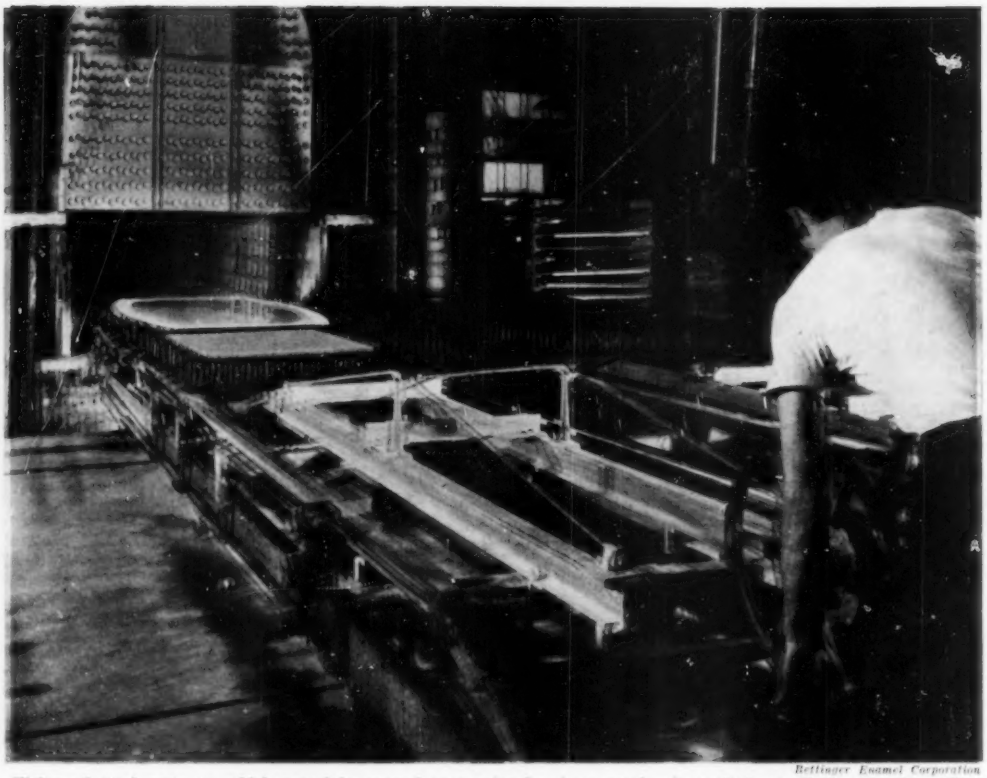
At present, 48 of the colleges are working with industry and business. Moreover, 514 trade associations are now either cooperating or ready to cooperate with colleges in the Association, and the assistance of others as well as that of key business leaders is being sought. Examples of the cooperation between some of the colleges and purchasing agents associations are the courses in purchasing given at Boston University, Butler, Northwestern, Roosevelt College, University of Toledo, Tulane and Wayne. Other examples are the traffic courses given by nine colleges in cooperation with associations in the traffic field. University of Pittsburgh and Illinois Institute of Technology have courses adaptable to defense needs.

The courses will be divided between functional and industry topics. Examples of the former are "Office Techniques and Management" and "Labor Relations". The textile, food and building industries are among those covered in the industry courses.

Porcelain Enamel Coatings

Production line in Hotpoint electric range plant shows porcelain enameled parts handled by conventional assembly methods.

Porcelain enamels have graduated from the sanitary ware field. There are now hundreds of formulations available for many different property requirements—a new type allows one-coat application directly on steel. And the color need no longer be limited to white—practically any color is now available. The result is a "boom" in porcelain enamel—use in appliances and in industry is becoming widespread.



Bettinger Enamel Corporation

Firing of steel parts to which porcelain enamel suspension has been previously applied, usually by spraying. Wet process enamels are "matured" in enameling furnaces of this type, at temperatures around 1500 F. The tendency in recent practice is to lower firing temperatures, especially for enameling the surfaces of products made of aluminum.

PORCELAIN ENAMELS differ in essential composition from both the organic coatings and the chemical and electrolytic inorganic finishes. They are composed of inorganic materials, ceramic in nature, and are fused onto metals at relatively high temperatures. Characteristics that make them attractive to product designers include excellent chemical and corrosion resistance, heat resistance, scratch resistance and extreme hardness. They can also be produced in a wide range of colors and finishes, from very high gloss to matte.

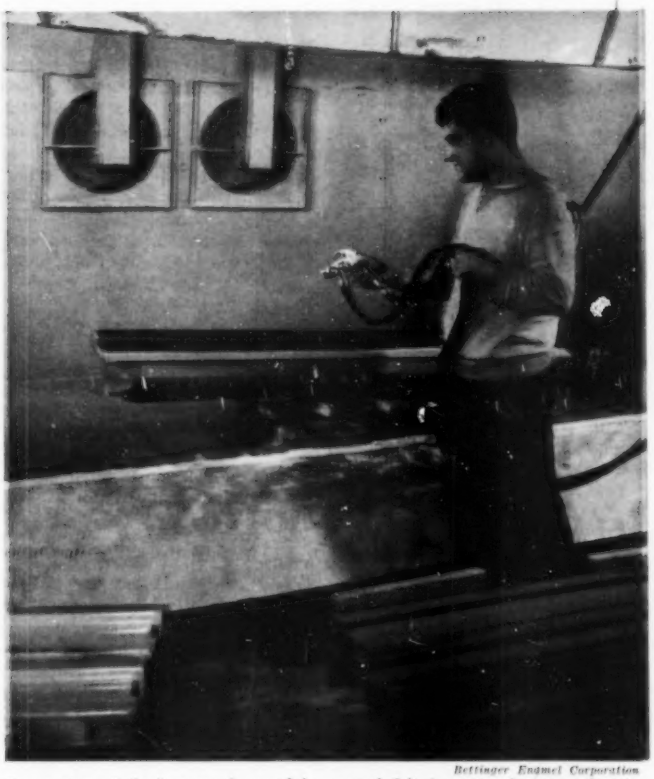
Essential ingredients of porcelain or vitreous ("glass-like") enamel coatings are silicates, feldspar, borax and soda ash, properly proportioned and melted together at approximately 2300 F. This molten mixture is quenched in cold water to form a mass of shattered particles called frit. The frit is ground to a fine powder with additional ingredients such as opacifiers (oxides of titanium, antimony, zirconium and tin) and pigments (usually colored oxides of cobalt, iron and the like).

Application Methods

Porcelain enamels are applied to metal products by the wet or dry processes. The dry process is the older method, and is now used almost exclusively for cast iron parts. In the dry method, a wet "ground coat" is first dipped or sprayed on the casting. Ground coats are applied mainly to give better adherence between cover coat and base metal, to prevent surface defects that might result from interaction of base metal and cover coat, to prevent oxidation of cast iron at high temperatures, and to smooth over surface irregularities.

The dry process consists of dusting dry, finely ground frit on the ground coat of a part heated to a about 1600 F. The part is then returned to the firing furnace. This process is usually repeated, to build up the desired thickness; on cast iron, this is usually 0.04 in., with a minimum of 0.025 in. Enamel thicknesses are usually greater in the dry than in the wet process.

The wet process is the newer method, and is preferred for sheet metal and medium and small castings. Finely divided frit is milled with clay and certain electrolytes, to form a suspension in water called "slip." Ground-coat enamels are usually applied to sheet steel by dipping and draining; one or two cover coats are then applied by spraying. The parts are returned to the oven for water removal be-



Bettinger Enamel Corporation

Suspension of finely-ground porcelain enamel frit in water is sprayed onto metal part through an air spray gun. Water content is carefully controlled. If coating must be uniform, parts are weighed before and after spraying.

tween coat applications. The parts are then fired in an enameling furnace at temperatures somewhat lower (1400–1550 F) than those used in the dry process. Recent practice is to lower firing temperatures, especially for enameling such materials as aluminum.

Types of Enamels

Porcelain enamels are difficult to classify, in the same sense that metals or plastics can be subdivided into "families" of materials. An over-all classification might be made on the basis of color and transparency: (1) "White opaque" enamels—these enamels are opacified with zirconium, antimony and titanium compounds; (2) clear glasses—strong "pure" colors are created by adding pigments after the frit is made; and (3) "colored" enamels—clear glasses in which the colors are melted in the frit—strong dark colors.

Of these types the "white opaque" enamels are of most interest to product designers. They are used on most appliances, and can be colored. These materials can be classified according to opacifier, color and acid resistance:

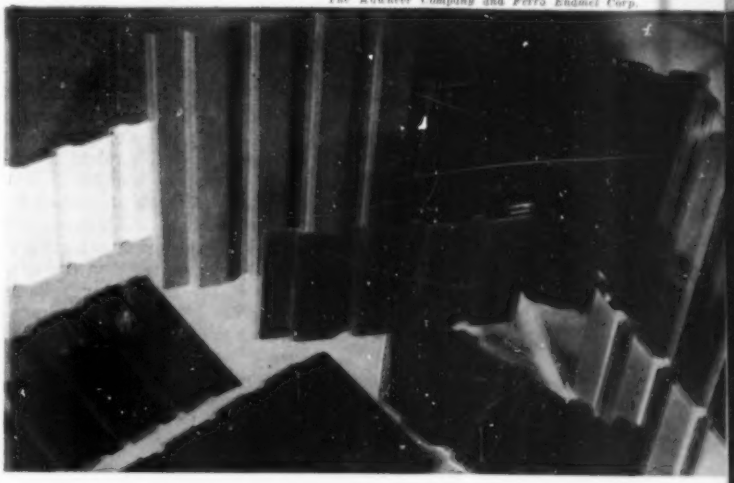
Zirconium-base opacifiers: Enamels containing these materials can be made in white and colored finishes, but all are non-acid resisting. Thus, some colored electric ranges have certain parts made of zirconium enamels, but parts expected to contact food receive a "dust coat" of acid-resisting enamel. One alkali-resistant zirconium type is sometimes applied to washing machines. They are more resistant to thermal shock than antimony types.

Antimony-base opacifiers: These enamels can be produced in both acid- and non-acid resisting types. These can be produced in even greater acid resistance than the titanium types if needed, but an intermediate coat is required. They can be made in both white and colored effects, and are available in opacities ranging from about 60 to 75 percent light reflectance.

Titanium-base opacifiers: Recently titanium opacified enamels have aroused interest because of

Two new developments in the porcelain enamel field are enameling directly on aluminum extrusions (shown below) and the greater use of color in enamels.

The Kawneer Company and Ferro Enamel Corp.



NEW DEVELOPMENTS

LOW-TEMPERATURE ENAMELS. Recent development work has been directed toward producing sheet steel enamels that can be fired at lower temperatures—in the neighborhood of 1350 Fahrenheit. Successful commercial applications have been made, but their use has not yet become widespread. White enamels for direct application on special steel have been produced in the low-firing types; titanium opacified enamels fire at 1450 F, compared with the zirconia enamels which require 1580 F. Lithium compounds are also being used in comparatively small percentages in these new enamels. The advantages of enamels firing at about 1350 F instead of 1500 F include the following: (a) Being below the critical deformation point of steel, there will be much less tendency for warpage, and lighter gage metal can be used with a consequent lowering of costs; (b) lower fuel or power costs and lower maintenance cost of enameling furnaces.

Development of low temperature frits means that porcelain enamel can compete economically with baked organic finishes on such products as refrigerators and home freezers.

ENAMELING ON ALUMINUM. Enameled aluminum extrusions are lightweight, can be easily cut to shapes and sizes on the job, and exposed edges after cutting do not oxidize to the detriment of the porcelain enamel finish. The product can be bent to a rather sharp angle without hurting the finish, and the metal can be reformed after porcelain enameling to reasonably complicated angles. Adherence is excellent, and a variety of colors can be produced.

On the basis of these very distinct advantages, it is quite obvious that porcelain enameled aluminum can take a definite place where a lightweight, non-corroding material is required. Aluminum has the advantage of lightweight but in some coastal and industrial areas, it cannot be used outdoors without a finish. An example is on LST boats, or any type of water conveyance that may carry fuel and cargo but is limited in its carrying capacity because of the heavy materials used in its construction; porcelain enamel on aluminum would allow the speed and carrying capacity to be increased. The same reasoning might apply to automobiles, trucks and railroad cars operating in salt water or other corrosive atmospheric conditions.

Biggest production difficulty is warpage in the base metal during firing. With present frits, the enamel matures at approximately 970-1000 F, only 100 degrees from the critical temperature of the metal itself. At the firing temperature, therefore, the metal is in weakened condition and will sag, warp or bend. Also, the glass requires approximately a 15-min firing period for complete maturity. Exposing the metal to the high temperature for such a long period contributes to increasing warpage.

Two developments are being sought to lick the warpage problem: A frit that will mature at a lower temperature, around 850-900 F, or that will mature much more quickly—in 5 to 3 min as is commonly done in sheet steel enameling—holds the answers.

Porcelain enameling aluminum still requires too many firings. For example, a separate firing or heat treating operation is needed after metal pickling, besides firings after the ground coat and each of the cover coat applications. Some better method of preparing the metal for enameling is needed to eliminate the pre-firing treatment; in addition, development of single-coat enameling directly on metal, similar to the one-coat method for steel is needed for this product to become economical.

COLORED COATINGS. For appliances, colored enamels are made from "white opaque" frits, using metallic oxide pigments. However, it has not been done on a wide scale because of the number of variations in shades and the number of colors that could be used, creating a problem of obsolete stocks of appliances. An attempt has been made through the Porcelain Enamel Institute to standardize on shade but not too much progress has been made.

their ability to be applied in thin coats, and high resistance to acids, scratching and thermal shock. Development of a titanium-bearing sheet steel has enabled one-coat enameling of some appliances, with consequent elimination of a ground coat. This is made possible also by the excellent covering power of these enamels. This development will be described later in greater detail. At present these enamels can be finished in white only.

Properties

ABRASION RESISTANCE. Porcelain enameled metal parts have a hard durable finish—"hardness" is usually considered as a measure of ability to resist abrasion or scratching. The most common method of determining hardness is the scratch test, using Moh's scale, in which an attempt is made to scratch the porcelain enameled surface with samples of minerals of varying degrees of hardness. If the porcelain enamel is scratched by a particular mineral it is softer than the mineral and the next lower scale is tried. The highest numbered mineral which will not scratch the enamel is given as the hardness number of the enamel. Most porcelain enamels have a hardness number between five and six in the Moh's scale. This is comparable to a Brinell hardness of about 500 or a Rockwell "A" of about 70, and is considerably harder than organic finishes and most plastics. Some recently developed enamels are so hard that it is difficult to scratch them with a sharp tool steel blade; these have better scratch resistance than many metallic coatings.

The following table shows results of a scratch adaptation of the Porcelain Enamel Institute standard gouge apparatus, as reported by Dr. G. H. Spencer-Strong of the Pemco Corporation:

Finish	First Visible Scratch, grams	Readily Visible Scratch, grams
Organic A	60	60
Organic B	28	40
Chrome Plate	20	20
Titanium Enamel	1600	2000

Organic coating A is a new 420 F type material, while organic coating B is the alkyd-urea type widely used in industry. Since a modified silicone showed a hardness slightly less than organic coating B, the two may be considered as comparable. The reduced resistance of the chrome plate to scratching was intensified by the high polish of material used in the test. The hardness and abrasion resistance of porcelain enamels contribute to its "smoothness". The characteristic of low friction is responsible for its use in conveyer piping in grain elevators, and as bearings and guides in textile machinery.

THICKNESS. The thinner the enamel coating the less tendency there will be for the enamel to sustain damage when subjected to mechanical shock. Improvements in enamel frits enable much thinner coatings to be applied—thicknesses are about 20 percent of those required fifteen years ago.

CHEMICAL AND CORROSION RESISTANCE. When choosing an enamel for best corrosion resistance, type of metal, product to be enameled, and expected usage must all be considered.

Porcelain enamels are not resistant to the action of hydrofluoric acid or strong alkalies. Acid resistance in porcelain enamels varies from non-acid resisting enamels to the highly resisting chemical ware enamels, which are used as linings for tanks, pipes, valves, and similar equipment. Relative acid resistance

of porcelain enamels can be rated in accordance with standard grades established by the Porcelain Enamel Institute. These run from the highest acid resistance, Class AA, to the lowest, Class D, as follows: AA, A, B, C, D. "Acid-resisting" types do not rate below Class A.

In a comparison test of organic and porcelain enamel coatings, a 3 hr immersion in boiling water affected only the alkyd-urea, which showed a very slight blistering. When exposed to the humidity cabinet for 200 hr, the porcelain enamel and the modified silicone were unaffected; the alkyd-urea showed a very slight blistering; the 420 F organic coating was unaffected in 200 hr but after 14 days developed a slight creaminess.

WEATHERING. Resistance to weathering has been tested by the National Bureau of Standards, on porcelain enamel panels of various types exposed at Washington, D. C., St. Louis, Mo., Lakeland, Fla., and Atlantic City, N. J. As reported in the *Journal of Research*, January, 1949 (by W. N. Harrison and D. G. Moore) results of the seven-year tests can be summarized as follows:

1. There is good correlation between acid resistance and the percentage of initial gloss retained, the enamels of best acid resistance retaining the highest percentage of their original gloss.

2. No noticeable fading of enamels of class AA or class A acid resistance occurred, nor was there objectionable fading of class B enamels. Practically all class C and class D colored enamels, however, showed noticeable color change.

3. Conditions at Atlantic City were slightly more severe than elsewhere on the acid-resistant enamels, but Lakeland conditions were most severe on the nonacid-resistant compositions.

THERMAL RESISTANCE. Thermal resistance and thermal shock resistance of porcelain enamel is a function of the enamel composition and certain physical properties rather than any general type of material. All porcelain enamels show excellent resistance to heat up to 800 F. Special formulations will resist much higher temperatures. In general, titanium opacified and acid-resistant types of antimony opacified enamels show best thermal shock resistance.

The heat emitting value of porcelain enamel compares with other materials as follows:

Material	Emissivity	Reflectivity
Aluminum, bright	4.0	96.0
Aluminum, dull	4.1	95.9
Galvanized Iron, fresh	4.4	95.6
Stainless Steel, No. 7 finish	13.6	86.4
Stainless Steel, No. 2B finish	15.8	84.2
Porcelain Enamel, white overcoat	77.4	22.6

These values show porcelain enamel to be a heat resisting material that gives off heat rapidly; this is an advantage in heating applications.

IMPACT RESISTANCE. Organic and porcelain enamel coatings have been tested for impact resistance using a drop weight test at 2, 4, and 6 ft-lb. In this test, the alkyd-urea coating was unaffected by the 2 ft-lb blow but was broken by the 4 and 6 ft-lb blows. The modified silicone was shattered by all three, and the 420 F type organic coating was very badly shattered. Porcelain enamel was very badly shattered by the 6 ft-lb drop but was not as badly affected by the 2 and 4 ft-lb drops as was the 420 F organic. However, when the porcelain enameled metal sheet specimen was backed by 11/16 in. plywood it was unaffected by 2 ft-lb test.

PROPERTIES OF WHITE COVER COAT PORCELAIN ENAMELS[1]

Property	Antimony Opacified		Strontium Opacified	Titanium Opacified
	Acid Resistant	Non-Acid Resistant		
Commercial Application Weight, g/sq ft	Not used alone[2]	60–90	50–65	10–25
Commercial Reflectance, percent	60–65	73–75	75	70–85
Maturing Temperature, F	1530	1500–1530	1530	1430–1480 1480–1530
Maximum Reflectance Reached at g/sq ft	.....	130	75	23–30
Acid Resistance, P. E. I.	AA–B	D (none)	D (none)	AA–B
Alkali Resistance 2% NaOH-boiling[3]		Fair	Good	Fair to Good[3]
Color Change on Heating	None	None	None	None
Color Change on Exposure to Ultra Violet Radiation	None	None	None	None
Resistance to Staining	Excellent	Excellent	Excellent	Excellent
Scratch Resistance	Excellent	Very Good	Good	Excellent
Torsion Resistance, P. E. I., Avg. Coating Thickness 0.006 in.	.....	.....	.....	70
0.009 in.	.....	31.5	32.5	41
0.015 in.	.....	34.0	37.0	32.5
Abrasion Resistance, P. E. I., percent retained gloss	60–75	50–65	50–65	75
Abrasion Resistance, mg Taber Abraser CS–17–F 10,000 Revolutions	40.9 10.2[4]	73.5	67.1	5–6 .....

[1] In the interest of simplicity special purpose enamels developed for particular end uses, and the unspecified enamels used as a basis for the production of colors, have been omitted. The unspecified types of enamels are available in both the acid resistant and non-acid resistant classifications. In general, their physical properties will be quite similar to the antimony opacified acid-resistant type enamel.

[2] Acid-resistant antimony enamels are not normally utilized alone. These enamels are usually applied either as a second coat over a non-acid resistant base coat enamel or as a partial or dust coat applied over a partial coat of non-acid resistant enamels.

[3] Most porcelain enamels show good to excellent resistance to cold alkali solutions. The data given for resistance to 2 percent boiling sodium hydroxide are comparative only, since enamels differ widely in this property. Special enamel formulations have been developed for this use.

[4] Data from "Better Enameling", Vol. 22, No. 1, January 1951, page 10.

[5] Ferro Corporation laboratory data.

(Courtesy Dr. G. H. Spencer-Strong, Ferro Corporation)

Base Metal Design Factors

CAST IRON. Most gray iron castings are suitable for porcelain enameling. For best results, however, they should have the following chemical composition (percent):

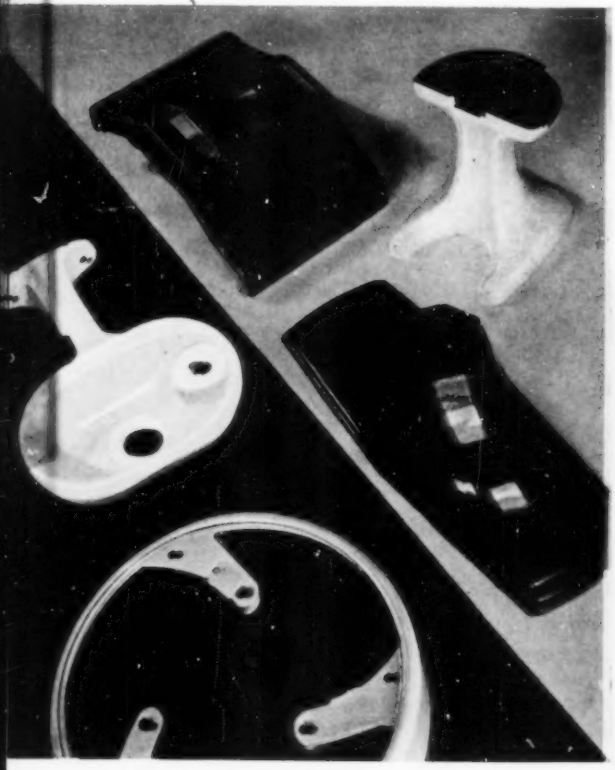
Total Carbon	3.25 to 3.60
Graphitic Carbon	2.80 to 3.20
Combined Carbon	0.30 to 0.60
Silicon	2.25 to 3.00
Manganese	0.50 to 0.70
Phosphorus	0.60 to 0.90
Sulfur	0.05 to 0.10

The use of facing materials in making the casting mold should be kept to a minimum and graphite facings should be avoided.

In preparing the casting for enameling, either sandblasting or blasting with a mixture of sand and grit is preferred to blasting with shot or grit alone. If the casting has been coated with oil or grease, has been stored in a damp place and has absorbed moisture, or has chilled spots, it should be annealed for several minutes at 1350–1450 F in the enameling furnace.

Wet process porcelain enamels, usually fired at relatively low temperatures of 1300–1400 F, makes this process well suited for light castings where warpage and distortion might be a serious problem. Dry process enameling is employed almost exclusively on heavy gray iron castings. The average thickness of cover coat dry process enamels is 0.040 inch. Dry process enamels are usually glossier and more brilliant than wet process enamels.

When iron castings are properly designed they can be successfully enameled by either the wet or dry process. Castings should have well rounded corners and edges. Porcelain enamel tends to pile up, chip and craze at sharp corners. The enamel tends to flow away from sharp edges with dark lines showing through where the enamel is thin. Castings should be designed to heat uniformly in the porcelain enamel process. If this is not done some sections will heat faster and as a result will be "over-fired" while other sections will be "under-fired", making an unsatisfactory finish.



Cast iron parts, porcelain enameled in various colors: Scale front, seat ring for soda fountain stool, malted milk dispenser, drinking fountain bowl, and restaurant table base. In these applications porcelain enamel coatings are used for increased sales appeal and excellent resistance to food acids.

The Chicago Hardware Foundry Company

Color in home appliances is now possible with porcelain enamel: These are only a few of the colors available in one line of gas ranges. Color pigments are mainly metallic oxides, which are mixed with the "white opaque" antimony or zirconium type frits. Red shades are made from cadmium and selenium compounds; blues and greens from cobalt, chromium, zinc and aluminum oxides; yellow from cadmium sulfide —and any intermediate shade can be obtained.

Chambers Corporation

Projections or uneven edges tend to heat first and must at times be made heavier to retard heating. Iron castings that are not properly designed often crack or warp in the porcelain enamel process.

SHEET IRON AND STEEL. Oil or grease must be removed; if this cannot be done by usual solvent methods, then grease is burned off at 1200–1300 F in a furnace. Sandblasting is rarely used, except for sheets thicker than 14 gage. Pickling is the most common method of preparing the sheet for enameling. The acid in the solution removes rust and other oxides. For better bonding of the ground coat to the steel base, a nickel "flash" of 0.04 to 0.08 g of nickel per sq ft is then applied by dipping.

Enameling "iron" should be low in carbon, manganese, phosphorus, sulphur and silicon, as compared to the same elements in mild steel. Carbon content is of utmost importance in enameling iron. It should be approximately 0.03 percent, mostly in the combined form as carbides, instead of free graphitic carbon, which forms gas pockets during firing, creating a tendency for the sheet to warp and sag.

Selection of the proper gage of metal is of primary importance if defects such as warpage, sagging, hairlining, and chipping are to be avoided. No hard and fast rule can be laid down as to the size of parts that can safely be made from any given gage, but it is better to err on the side of too heavy a metal than to use one too light.

Parts which are formed by drawing, but still remain largely flat in appearance, are usually more subject to warping than are those designed so that a drawing operation is unnecessary. This is due to unequal stresses set up in the metal, resulting from the drawing operation. Recourse to a heavier gage may overcome this difficulty. Sharp radii in drawn steel parts should be avoided; a radius should never be below $\frac{1}{8}$ inch. Where flanges are used, the minimum flange depth has been established at $\frac{3}{4}$ in. with all corners welded and ground to a smooth finish.

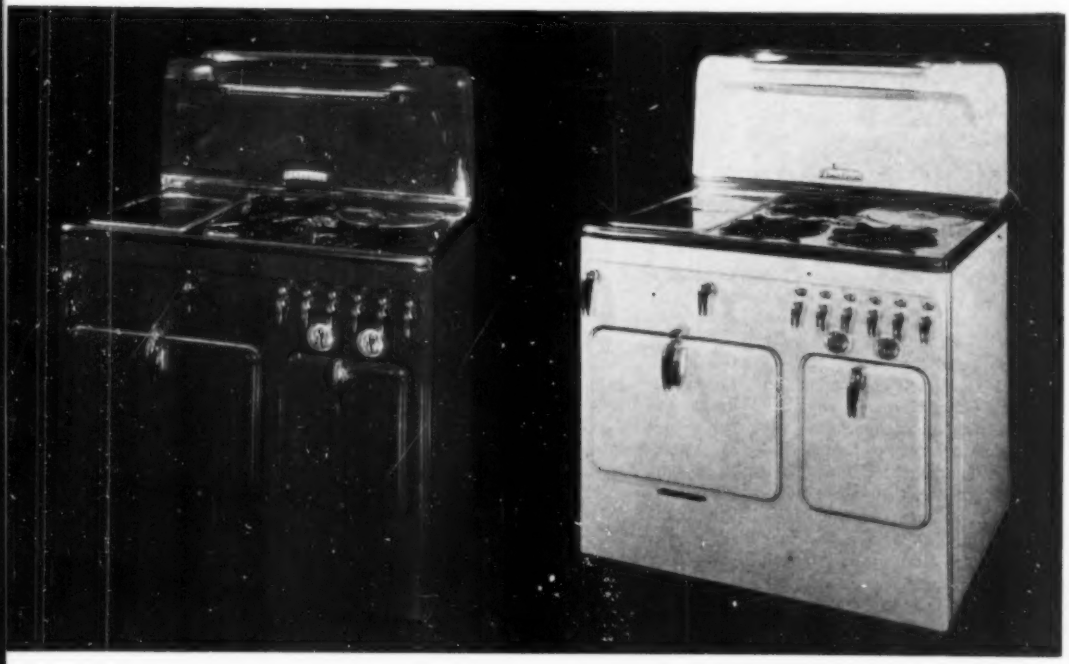
Since flanges are essential if parts are to be kept flat and straight, their depth is important. Where used for this purpose, the depth should never be less than $\frac{3}{4}$ in., and if punched with holes for mounting, $\frac{1}{2}$ in. is a more desirable minimum.

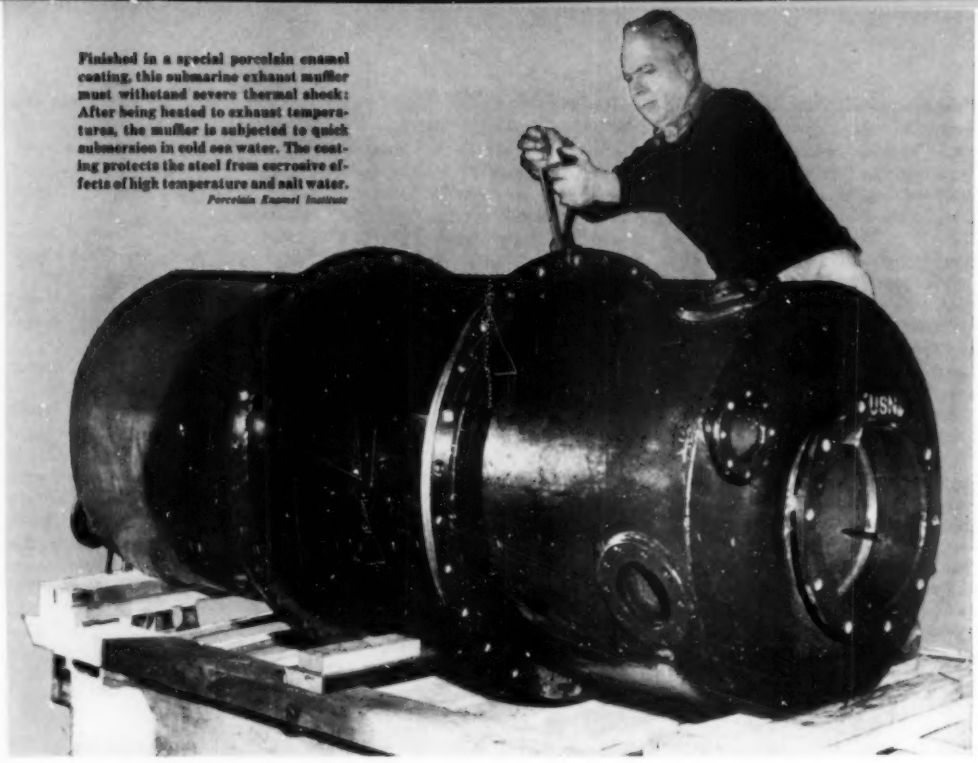
Bolt holes can be punched $\frac{1}{8}$ in. larger than the nominal bolt diameter. On account of the tendency of enamel to accumulate at the hole, an allowance of 3/32 or $\frac{1}{4}$ in. in punching is preferable.

In fabricating flat pieces, a plus or minus tolerance of $\frac{1}{16}$ in. is customarily allowed. Provision must be made in addition for maximum enamel thickness. While this is about 0.015 in. at the center it may be as high as 0.05 in. at the edge. Clearance for the enamel itself, therefore, should be about $\frac{1}{8}$ in. for each part. Still greater clearance, about $\frac{1}{4}$ in., must be provided for parts fitting into a corner, where the ground coat enamel accumulates during draining.

One Coat Titanium Enamel

As a radical departure from the conventional method already described of applying porcelain enamels over a blue-black ground coat,





Finished in a special porcelain enamel coating, this submarine exhaust muffler must withstand severe thermal shock: After being heated to exhaust temperatures, the muffler is subjected to quick submersion in cold sea water. The coating protects the steel from corrosive effects of high temperature and salt water.
Porcelain Enamel Institute

there have been developed in the past few years white enamels for sheet steel which are applied directly on the metal in one coat. However, it is necessary to use a special type of steel, of which several have been developed by the steel companies. One of them is a titanium alloy steel developed by Inland Steel in cooperation with Westinghouse, and called "Ti-Namel". This is a killed steel having greater soundness but also more surface defects than the usual rimmed steels—enameling iron and cold rolled steel. It would be advantageous if Ti-Namel were a rimmed steel but this is not possible since the titanium is a strong deoxidizer and hence would produce a killed steel when added in sufficient quantities to completely combine with the carbon.

The nominal composition of Ti-Namel is (percent): Carbon, 0.09 max; manganese, 0.50 max; phosphorus, 0.040 max; sulfur, 0.050 max; titanium, 0.20 to 0.50. Four times as much titanium is required as carbon. Since titanium is expensive, the aim is to keep the carbon as low as possible. The present analysis runs about 0.06 percent carbon and 0.30 percent titanium.

One of the interesting properties of the new steel is its high resistance to sagging and warping at enameling temperatures; sag of ordinary enameling iron is 2 to 3 times as great as Ti-Namel. The resistance of enameled parts to crazing at comparatively high temperatures is excellent. Enameled stove parts show no crazing around the burner openings after a period of three to four years. Also, the resistance of enameled Ti-Namel parts to thermal shock is quite high. The thin enamel coatings possibly account for a part of this resistance, but it is felt also that it also is due to inherent properties of the metal. Enamel coats applied to Ti-Namel do not fishscale regardless of the degree of enamel adherence, since titanium forms a rather stable compound with hydrogen it resists the flow of hydrogen through the metal sheet.

This material was developed for the application of white cover coat enamels directly to the metal. This is being done successfully in production with titanium acid resisting enamel, with the average coating thickness under 0.010 inch. The resistance of these thin coatings to chipping is extremely good.

The new titanium enamels have a reflectance of about 85 percent, which is an improvement over the zirconium and older types for the same thickness of coating. They also have greater color (white) stability, thermal shock resistance and acid resistance than the zirconium type; abrasion resistance is about equal. Acid resistance of titanium types is about equal to acid-resisting antimony types.

ACKNOWLEDGMENT

Thanks are due to the following organizations, for supplying information and illustrations on which this article is based: Armco Steel Corporation, Middletown, Ohio; Bettinger Enamel Corporation, Waltham, Mass.; The Chicago Hardware Foundry Company, North Chicago, Illinois; Erie Enameling Company, Erie, Pa.; Ferro Enamel Corporation, Cleveland, Ohio; Fox Company, Cincinnati, Ohio; Hotpoint, Inc., Chicago, Illinois; The Kawneer Company, Niles, Michigan; National Bureau of Standards (Enameled Metals Section), Washington, D. C.; Pemco Corporation, Baltimore, Md.; Porcelain Enamel Institute, Washington, D. C.; and Westinghouse Electric Corporation, Mansfield, Ohio.

I-T-E Circuit Breaker Co.

Reducing Cost Of Extrusions

FRANK McL. MALLETT, OHIO STATE UNIVERSITY

IN CONSIDERING THE DESIGN of an extruded part two things are presupposed. First, it is assumed that a cost analysis has been made to show that the part in question can be more economically made from an extrusion than from some other form of material, such as a forging, weldment or sheet. And second, it is assumed that the designer has already searched through catalogs of available extruded shapes and has not found a shape that will satisfy his particular structural and functional needs. By an "available extrusion" is meant a shape which is a standard warehouse item or a shape for which the supplier already has the extrusion die on hand.

Price Basis

Before considering production design details, the factors that determine the cost of an extruded shape should be considered. As in any material procurement problem, the size of the order affects the price. Here this factor is important only to the extent of pointing out that, if the same shape can be used for more than one part in a machine or assembly, it will increase the size of the order for that shape and thus lead to cost savings.

The cost of the extrusion die must be considered. This depends on the overall size or diameter of the circle that encloses the cross-sectional shape of the extrusion. However, this size is usually determined by structural or functional requirements, so there is little that can be done to reduce costs. Furthermore, this die charge is a relatively small part of the total cost and therefore low compared to the cost of forging dies or sets of rolls for the roll-forming of strip stock.

The base price assumes standard tolerances and lengths within the standard range. If lengths over the usual maximum of 36 ft are desired, a cost analysis should be made to determine the relative cost of making the part from one piece or from more than one. There is an addition to the base price per pound for shapes weighing less than 0.1 lb per linear foot, or measuring less than 0.0833 sq in. in cross-sectional area.

Shape Factor

Although consideration of die charge, extra lengths, tolerances and size of order must not be neglected, the really important factor in the cost of an extruded shape is a ratio called the "shape factor."

Friction between the metal being extruded and the edges of the hole in the die is a retarding force and this friction increases as the perimeter of a cross-sectional shape becomes greater. On the other hand, the force exerted on the metal being extruded is a product of the extrusion pressure exerted by the ram and the area of the cross-sectional shape. Therefore, the difficulty of extrusion, which increases with increasing perimeter, decreases with increasing area. Thus the ratio of perimeter to area will be a measure of extrusion difficulty, and it is not surprising that the base price per pound is made to depend on this ratio.

The shape factor is defined as the ratio of the perimeter in inches to the weight in pounds of one foot of the extrusion. Since the weight of one foot is the product of twelve times the area in square inches times the pounds per cubic inch, the shape factor F is

$$F = 0.83 \frac{\text{perimeter in inches}}{\text{area in square inches}} \qquad (1)$$

where the numerical factor is computed for aluminum alloy 24S-T and is arbitrarily used for other alloys including magnesium.

Fig. 1 shows how the cost per pound for extruded shapes rises with increasing shape factor. For this graph the abscissa is the shape factor F and the ordinate is a relative price scale in which the base price per pound of 0.040-in. sheet aluminum alloy 24S-T is taken as unity. On the same scale,

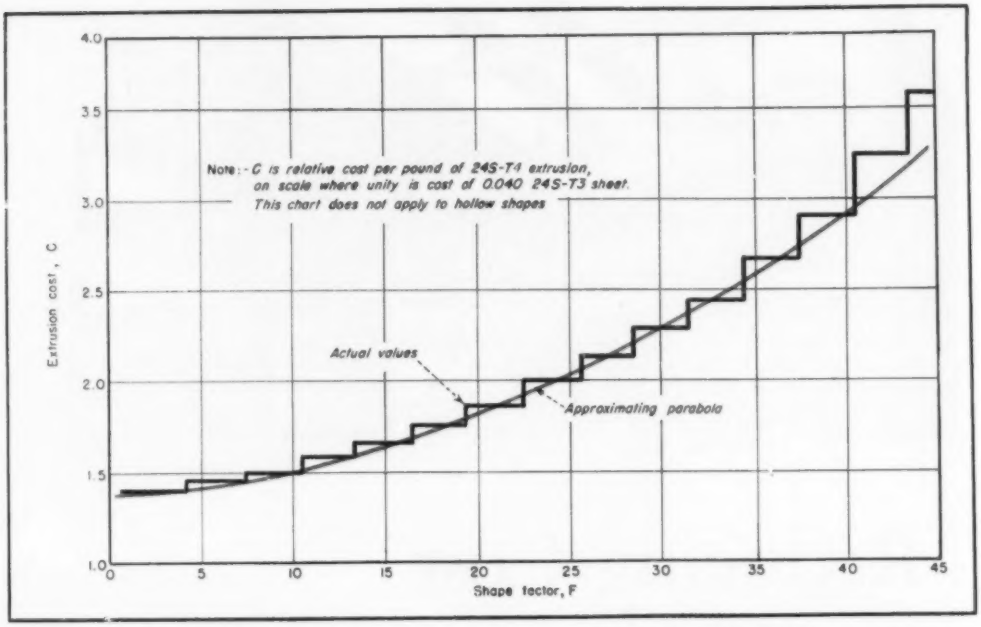


Fig. 1—For shape factors up to 34, the cost of extrusions increases almost parabolically. Above this critical value, the cost rises more sharply. Ordinate is a relative price scale in which base price per pound of 0.040-in. 24S-T alloy sheet is taken as unity.

the price per pound of 0.020-in. sheet is about 1.21 and of 0.81-in. sheet, about 0.88. The increase in cost with increasing shape factor is seen to be non-linear and, compared to a parabola which approximates the smoothed curve for F less than 34, there is a noticeable change in the rate of increase.

Because of the almost unlimited variety of shapes that extrusions can take, it is impossible to give a formula for shape factor in terms of the dimensions of the shape. Formulas would have to be derived for each separate shape. However, many of the existing extruded shapes have constant thickness, especially if fillet and corner radii are ignored. Fig. 2 shows some of the common shapes for which T is the thickness and L is the sum of the leg lengths (A plus B or H plus W). A closely approximating formula for the shape factor for these sections is

$$F = 1.67\ (T^{-1} + L^{-1}) \qquad (2)$$

The term containing L generally contributes very little to F because L is usually large compared with T. Therefore, in a great many cases, the formula can be simplified to take the following form

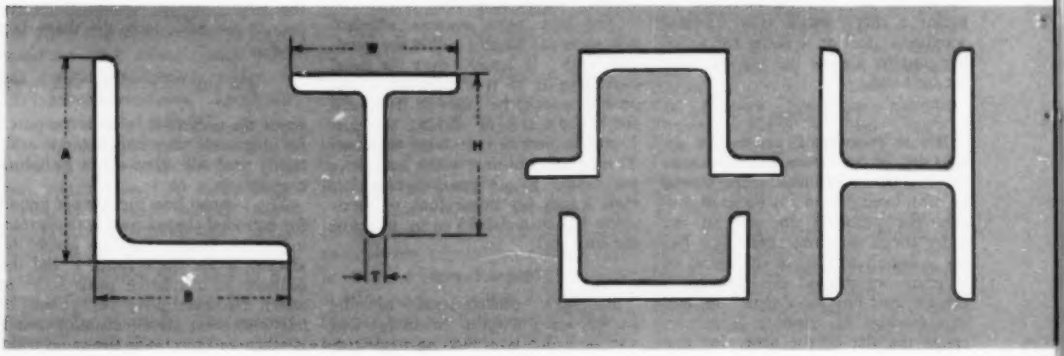
$$F = 1.67/T$$

Fig. 3 is a chart for Eq (2) which can be used for quick determination of shape factor for shapes of uniform thickness.

The effects of these shape relationships on design are significant. For extrusions of uniform thickness, the shape factor can be lowered by increas-

Fig. 2—Common extruded shapes having uniform thickness T. Sum of leg lengths A and B or H and W is the term, L in the shape factor formula.

Fig. 3—Curve represents shape factor equation for extrusions having uniform thickness T. Symbols F^1 and K are functions of T and K, respectively.



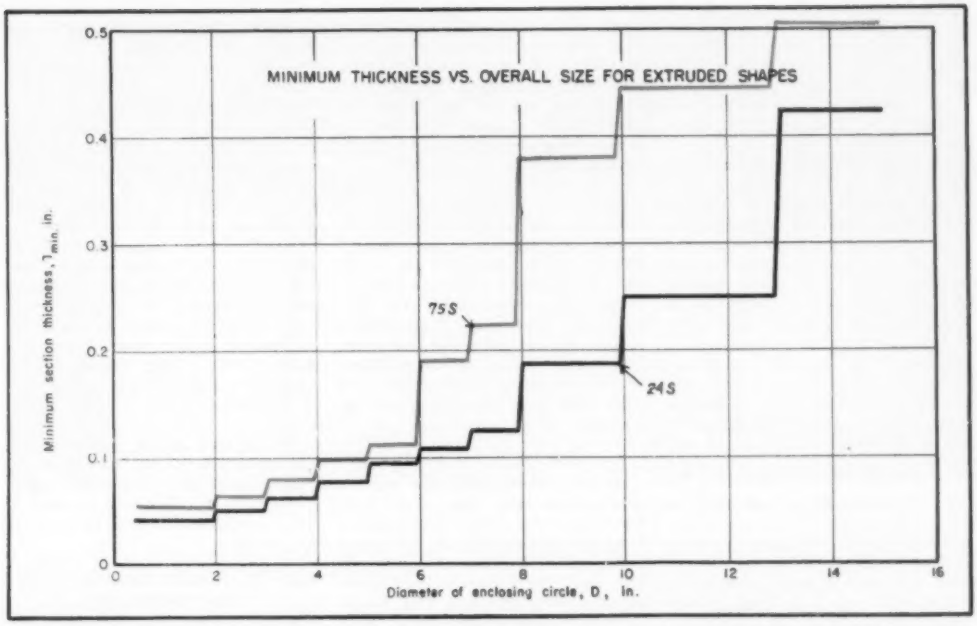


Fig. 4—Once the diameter of the circle that encloses the cross-section of a given shape is known, the minimum leg thickness consistent with economical production can be determined. Chart does not apply to hollow shapes for which T_{min} is larger.

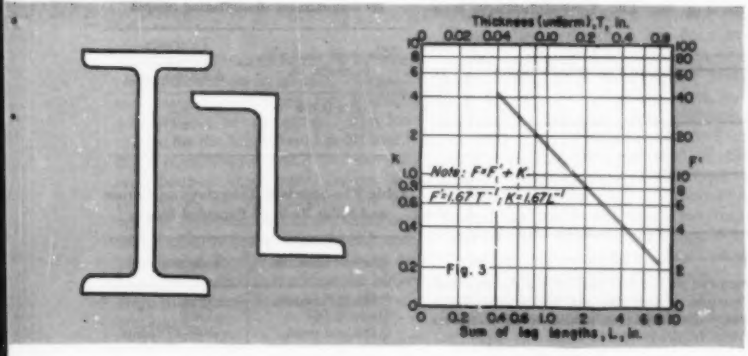
ing the thickness. This, in turn, increases the weight. The cost per pound is lowered and the number of pounds increased. However, there is a critical value of the shape factor above which the opposite is true. For shape factors above 34, the critical value, the cost can be reduced by increasing the thickness. The designer should therefore avoid shape factors above 34. In case functional needs demand a higher shape factor, some other solution to the design problem should be found and a careful cost analysis made to determine whether or not the alternative design is cheaper than a high-shape-factor extrusion. Of the many common available shapes, few have factors exceeding 34 so that major revisions for any given design are seldom necessary.

Other valuable data can be obtained from Eq (2). Taking 34 as the maximum shape factor, the minimum T for large values of L is about 0.050. For T equals 0.06, the minimum L is about 0.27; for 0.07, the minimum L is about 0.16 and for 0.08, the minimum L is about 0.13. In actual design, these minimum L requirements do not prove to be very restrictive.

Computations for some of the solid geometrical shapes are also of value. Table I shows minimum area and dimensions for some of the common shapes, computed on a basis of a maximum shape factor of 30. Of course, these common shapes are not always extruded, because some can be procured as bar and rod stock. Nevertheless, Table I is useful because some extruded shapes approximate these common shapes, and therefore the table gives an approximation of the size limitations that shape factor places on such shapes. Here again, the limitation is not serious, the minimums being relatively small.

Table I—Minimum Area and Dimensions for Common Shapes

Shape	Minimum Area, sq in.	Dimension, in.
Circle, diameter D	0.0094	D=0.109
Square, side S	0.0123	S=0.111
Rectangle, $L = 2W$	0.0138	W=0.083
Rectangle, $L = 5W$	0.0222	W=0.067
Rectangle, $L = 10W$	0.0372	W=0.061



Overall Size

Another limitation on the design of extruded shapes is the overall size, which is determined by the diameter of the smallest circle enveloping the shape. This limitation is not so much one of cost, but rather one of procurement. The diameter of this enclosing circle controls the size of the

die, which in turn is limited by the size of the extrusion presses. Before designing an extruded shape with an overall diameter greater than 10 in., a check should be made to determine whether there is a sufficiently large press available.

The upper limit on overall size is not the only size factor that must be considered in design. When the diameter of the enclosing circle is large, it becomes increasingly difficult to force the metal through thin sections in the die, especially if one part of the shape is thick and another part is thin. Fig. 4 shows suggested minimum thicknesses plotted against D, the diameter af the enclosing circle. Another way of applying this limitation is to lower the maximum allowable shape factor for larger values of D, but this methoa is not recommended.

Die Projection

An extruded shape containing a channel-like section necessitates a projection on the die. If this projection is too long for its width, the force of the metal against it during the extruding process will cause it to bend or even break. The length of such a projection should not be more than three times its width of such alloys as 14S, 17S, 24S and 75S. It can be four times the width for alloys such as 3S, 53S, 61S and for magnesium alloys. If the functional needs of a part dictate a deep channel of dimensions at variance with the above, the part can be extruded with the legs forming a "V". After extrusion the legs are bent to the desired parallel position. This extra operation increases cost, but in some cases is justifiable.

Table II—Standard Tolerances for Metal-Dimensions in Cross-Section of Extruded Shapes

Dimension (d), in.	Tolerance, in.
$d < 0.125$	±0.006
$0.125 \geq d < 0.25$	±0.007
$0.25 \geq d < 0.50$	±0.008
$0.50 \geq d < 0.75$	±0.009
$0.75 \geq d < 1.00$	±0.010
$1.00 \geq d < 1.50$	±0.012
$1.50 \geq d < 2.20$	±0.016
$2.00 \geq d < 4.00$	±0.024
$4.00 \geq d < 6.00$	±0.034
$6.00 \geq d < 8.00$	±0.044
$8.00 \geq d < 10.00$	±0.054
$10.00 \geq d < 12.00$	±0.064
$12.00 \geq d < 14.00$	±0.074
$14.00 \geq d \geq 15.00$	±0.080

Radii

Corner radii are not of extreme importance in extrusion design, although they do help to extend the life of the die. A minimum radius of 0.01 in. is generally recommended for both corner and fillet radii. Many standard shapes embody only the minimum radii, while some uniform-thickness shapes incorporate both corner and fillet radii that are equal to the thickness.

Lengths of Extrusions

When extruded pieces are ordered in lengths ranging from 3 to 36 ft, there is no extra charge. Shorter pieces carry a premium rate, as do longer pieces up to a maximum of 90 ft. For shapes of relatively large cross-sectional area, an extra long length requires a large capacity press. Here again, the availability of proper equipment should be checked.

Tolerances

Standard tolerances should be used whenever possible. With simple shapes, it is sometimes possible to use smaller tolerances, but this is not advisable except with permission from the supplier. With complicated shapes, it is sometimes necessary to have tolerances even larger than standard. Again, the advice of the supplier should be sought.

For tolerances on the dimensions of cross-sectional shapes, it is necessary to distinguish between metal dimensions and space dimensions. A dimension that is at least 75 percent metal is called a metal dimension; otherwise it is a space dimension. An example of this distinction is the shape in Fig. 5. The 1.50 dimension is a metal dimension at the closed end and a space dimension at the open end. These two kinds of dimension are subject to different standard tolerances. The space-dimension tolerances vary with the length of the extended legs and can be from two to three times the metal dimension tolerance. For the example shown in Fig. 5, the tolerance for the 1.50 dimension at the closed end would be, from Table II, ±0.016. At the open end it would be ±0.050. In the few unusual cases where this increase in tolerance would not be acceptable for functional reasons, the supplier should be consulted. An increase in price would almost certainly result if closer tolerances were specified and this increase would have to be justified before a design is approved.

In addition to the tolerances on the dimensions of the cross-sectional shapes, there are four other types of tolerance that should be considered. These are listed in Tables III through VI, inclusive.

Table III—Standard Straightness Tolerances for Extrusions

Diameter of enclosing circle, in.	Allowable deviation from straight, per ft of length, in.
Under 1½, least thickness 0.094 or under	0.0500
Under 1½, least thickness over 0.094	0.0125
1½ and over	0.0125

Table IV—Standard Tolerances on Twist of Extrusions

Diameter of enclosing circle, in.	Allowable twist per ft of length, deg
Under 1½	1
1½ to 3	½
3 and over	¼

Table V—Standard Tolerances on Angular Dimensions of Extruded Shapes

Minimum thickness in shape, in.	Tolerances on angular dimension, deg
Under 0.188	±2
0.188 to 0.750	±1½
0.750 and over	±1

Table VI—Standard Tolerances on Corner and Fillet Radii of Extruded Shapes

Size of radius, in.	Tolerance, in.
"Sharp" corners	±1/64
Under 0.188	±1/64
0.188 and over	±10% of radius

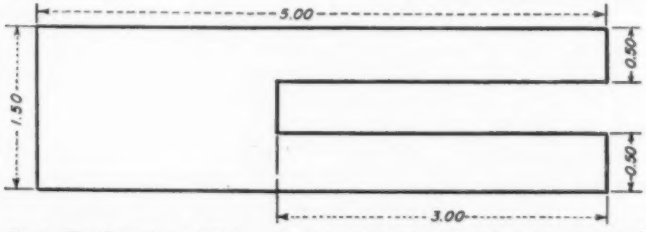


Fig. 5—The dimension "1.50" is a metal dimension at the left end of the channel and a space dimension at the right end. The proportions of this part are not in accordance with good extrusion design because the necessary die projection would be subjected to an excessive bending load.

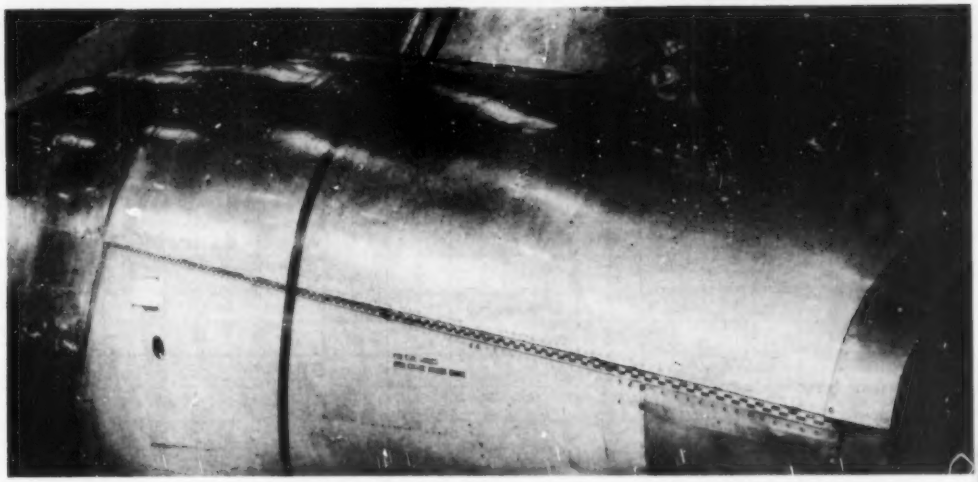


Fig. 1—Typical hinge application on the engine access door of an experimental Martin airplane.

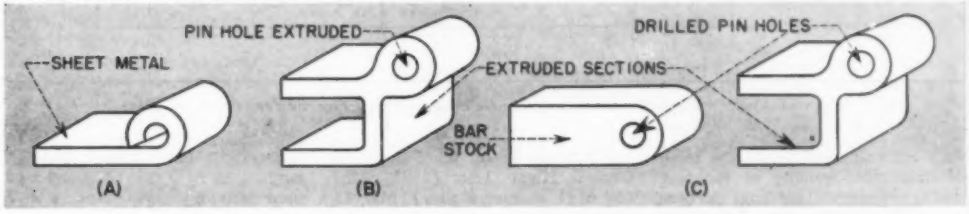


Fig. 2—Forms of piano-type hinges used in aircraft applications. (A) Leaf bent up of sheet metal. (B) Leaf made from an extruded section with pin hole formed in extrusion. (C) Leaf with pin hole drilled in bar stock or in an extruded section.

Hinges for Fastening Structural Parts

HAROLD G. BRILMYER
Structural Research Engineer,
The Glenn L. Martin Company

TO IMPROVE ACCESSIBILITY, it has been common practice in aircraft design to use piano-type hinges for attaching access doors to air-frames. The load carried by the hinges in such an assembly is usually quite small and the ordinary bent-up sheet metal hinges have proven to be satisfactory. To save weight, however, and at the same time to be able to manufacture more complex hinge configurations, it soon became the practice to machine the hinges from high strength aluminum alloy extrusions.

As a result of this practice, the use of the piano-type hinge has been extended to highly loaded non-rotating applications, such as attaching wing tips, cowlings, wing leading edges, and stabilizers, wherein the particular assembly can be quickly removed by simply pulling the pins out of the hinges. While hinges of this type as currently designed do fulfill their purpose, they could with some modification of their dimensional proportions be structurally more efficient when judged on a strength weight ratio.

Three forms are shown in Fig. 2 in which piano-type hinges are available.

Type A hinges are bent-up of sheet metal; these are made of steel and of aluminum. They are available only in the simple flat leaf as shown and are recommended for lightly loaded applications since the bent-up tangs open under a relatively low load.

Type B hinges have their leaf part manufactured from 53S or 61S aluminum alloy extrusions, in which the pin hole is formed during extrusion through the die. The leaf section can be extruded into almost any desired shape and has no seam at the tang to open under load. Close quality control is necessary, however, to insure that the material adjacent to the pin hole

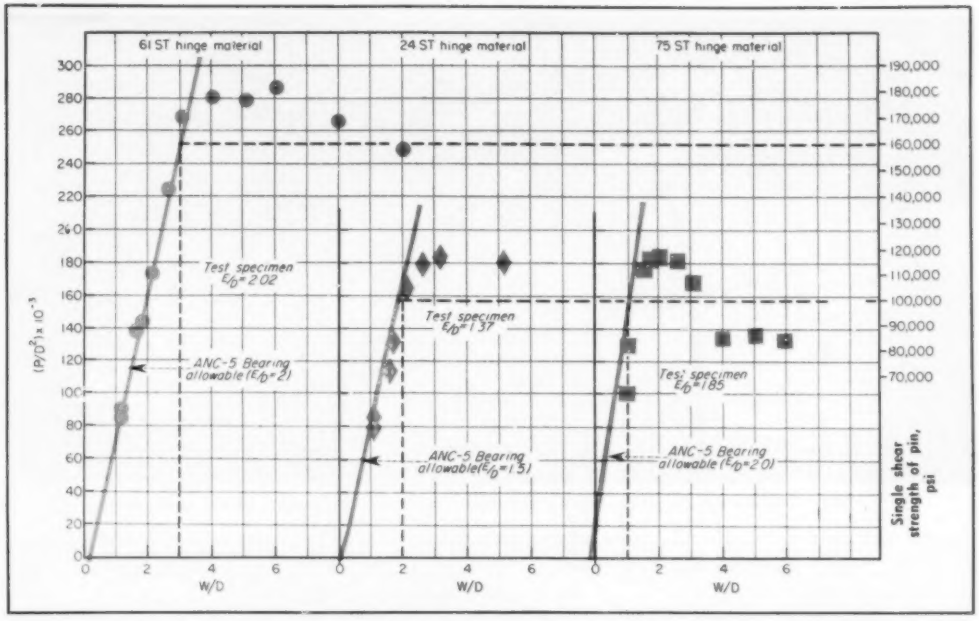


Fig. 4—Ultimate strength data for drilled pin hole hinges made of three different aluminum alloys.

does not contain defects as a result of incomplete welding of the tang during extrusion. This hinge has been restricted to applications, where the loads are low or where large safety factors can be maintained.

Type C hinges have drilled pin holes. These hinges are fabricated from the 24S and 75S aluminum alloys in which it would be difficult or not practical to form the pin hole in an extruding operation. Type C hinges are either machined from bar stock or from extruded sections. The high cost of drilling the pin holes in long hinges has restricted these hinges to the more highly loaded non-rotating applications.

In presenting the following non-dimensional method of analysis for hinges having drilled pin holes loaded as shown in Fig. 3, use will be made of the data contained in North American Aviation Report No. NA-48-630 General Hinge Tests (24ST, 75ST and 61ST aluminum alloy), May 26, 1948.

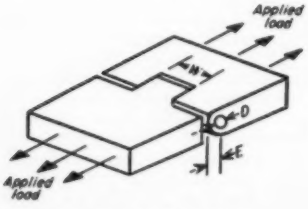


Fig. 3—Test loads on specimen hinge having drilled pin holes.

Optimum Design of Structural Hinges. The parameters that affect optimum design are: Hinge material, edge distance of the pin hole, length of the tang, diameter of the pin, and pin material.

Where

P = test ultimate load per tang, lb
D = pin dia, in.
W = tang length, in.
E = edge distance, in.

the series of test curves shown in Fig. 3, in which the ordinates are P/D^2 and the abscissas are W/D were obtained by plotting the ultimate strength data given in the North American Aviation report.

Where

S = strength of pin in single shear, psi

the ordinates for the values of the single shear strength of pin indicated at the right of Fig. 4 are plotted from the relations

$$P = 2\,(\pi\, D^2/4)S$$

or

$$S = 0.636\,(P/D^2)$$

A balanced design is obtained when a choice of W, D, and P/D^2 yield a value equal to the single shear strength of the pin.

Example *1*. For a hinge of 61ST material, an E/D ratio of 2, and a pin shear strength of 160,000 psi; a W/D ratio of 3 (from Fig. 4) gives a balanced design.

Example *2*. For a hinge of 24ST material, an E/D ratio of 1.37, and a pin shear strength of 100,000 psi; a W/D ratio of 2 (from Fig. 4) gives a balanced design.

Example *3*. For a hinge of 75ST material, an E/D ratio of 1.85, and a pin shear strength of 100,000 psi; a W/D ratio of 1 (from Fig. 4) gives a balanced design.

General Discussion and Proposed Criteria. The curves of Fig. 4 indicate that for a given edge distance and pin diameter, an increase in tang length will not always result in increased strength and may result in decreased strength. This decrease in strength from an increase in W/D results from the bending of the excessively long pin that concentrates the load at the corner of the tang, resulting in an early "tearing' 'failure. To get the best strength weight ratio, the choice of W/D should fall on the straight line portion of the curves.

The curves of Fig. 4, give optimum W/D ratios that are not practical under the present machining limitations, and the new tooling costs required to

produce hinges having these optimum ratios would be excessively high. Because of tooling difficulties, the minimum practical value attainable for W appears to be $\frac{1}{16}$ inch.

It should be noted that the test curves shown on Fig. 4 are only valid for the particular ratio of E/D indicated.

The slope of the straight line portion of the test curve, as a result of the choice of ordinates and abscissas, is actually the bearing strength of the material. The validity of this statement is easily checked as follows:

Bearing stress = (Load, lb) / (Bearing area, sq in.)

$$= \frac{P}{WD} = \left(\frac{P}{D^2}\right) \Big/ \left(\frac{WD}{D^2}\right) = \frac{P/D^2}{W/D}$$

The straight line, indicated on each of the curves in Fig. 4, was drawn through zero at a slope equal to the bearing value given in Table I, these values are taken from ANC-5, "The Strength of Metal Aircraft Elements." The actual bearing strength of the test specimens and the straight lines show good agreement.

The design curve for any other ratios of E/D would be constructed in the same manner, that is, by drawing a straight line through zero having a slope equal to the bearing strength of the material at the ratio of E/D to be used. The article "Analysis of Lugs and Shear Pins Made of Aluminum or Steel Alloys" by Cozzone, Melcon and Hoblitt, PRODUCT ENGINEERING, May 1950, p 113, contains comprehensive data on bearing allowable for practically all edge distance in steel and aluminum and is recommended for use in the construction of any new design curves.

Table I—ANC-5 Bearing Allowables for Plate Material

Material	E/D	Ultimate, psi	Yield, psi	1.5 × Yield, psi
61ST	2.0	88,000	56,000	84,000
24ST	1.5	90,000	60,000	90,000
75ST	2.0	154,000	not critical	.....

Conclusions

TANG LENGTH. Commercially available aircraft hinges have a tang length of $\frac{3}{8}$ in., giving ratios of W/D that exceed the optimum desired for small pin diameters. A standard tang length of $\frac{3}{8}$ in. would raise the efficiency of hinges to the level required for structural applications.

HINGE MATERIAL. Assuming constant edge distance and pin diameter, the optimum tang length becomes smaller as the higher bearing strength material is used. Considering the materials tested, it appears that 61ST aluminum alloy in optimum design would give more reasonable tang lengths. Alloy 75ST, however, requires extremely small tang lengths because of its high strength and its sensitivity to large W/D ratios.

PIN HOLE EDGE DISTANCE. The bearing strength of materials increases in proportion to the increase in edge distance. Therefore, maintaining reasonable tang lengths, it is recommended that an edge distance of 1 to $1\frac{1}{2}$ times the pin diameter be used. This ratio of E/D will give optimum ratios of W/D that are greater than the $2D$ edge distance tested.

PIN MATERIAL. The choice of pin material has usually been based on corrosion resistance, with the preference being given to stainless steel. These pins have a high shear strength equal to or greater than that of heat-treated alloy steel wire.

The acceptance of the $\frac{3}{8}$ in. tang length as a standard, desired by all hinge users, would soon amortize the expenditures that hinge manufacturers must make for the new tools needed to produce the optimum design.

Reliability Report on Electronic Computers

Large-scale electronic computers have received widespread attention since the war, but only a very few have reached the stage of regular productive computational activity. Since its dedication in June 1950, the National Bureau of Standards Eastern Automatic Computer (SEAC) has solved a large number of important problems. Until now, little or no reliability information has been available on any postwar high-speed electronic computer in regular use.

The new electronic computers are highly intricate, with tremendous numbers of components and connections. SEAC contains some 11,000 germanium diodes, 800 vacuum tubes, 500 pulse transformers, and 100,000 soldered connections. Failure even for a millionth of a second of a single one of these myriad connections and components will result in computer misfunction. These factors impose extremely severe design, construction, and maintenance requirements. Yet, tests show SEAC to be a highly reliable equipment.

Operations were scheduled on a 24 hours-a-day, seven-days-a-week basis during October, November, and December, 1950. In general, of each week's 168 hr, 16 were reserved for preventive maintenance, while 76 hr were allocated to engineering development and testing of new computer equipment. The remaining 76 hr were devoted to SEAC's primary mission, the solution of problems.

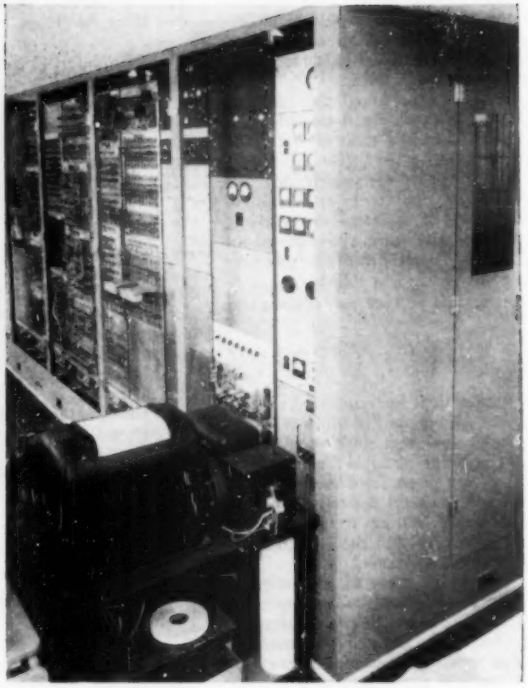
For the entire three months, 72 percent of the total time assigned to problem solution was "good" time. Week by week during the period the reliability trend was irregularly upward, with the figure reaching a high of 96 percent for the last week.

The "good" portion of the time dedicated to problem solution was that in which (1) either problem solutions or coding checks were turned out correctly by the machine, or (2) the machine was in good operating condition but idle. The machine was actually solving problems correctly during more than half (52 percent) of the time assigned to problem solution; coding checks took 17 percent of the time; and during only about 3 percent of assigned time was the machine in order but idle.

"Down" time—28 percent of the total hours allotted to problem solution—was a combination of time lost because of machine misfunction during problem solution (including the time used for re-running problems), time lost while machine difficulties were being diagnosed and remedied, and time during which the machine was out of order and idle.

SEAC was producing correct solutions during some 516 hr in the last three months of 1950. Since the machine can add or subtract pairs of 14-digit numbers up to 5,000 times per sec, and multiply or divide them 330 times per sec, an enormous number of individual mathematical operations are performed in each functioning hour. The great speed of the giant computer makes feasible the solution of lengthy problems. Because of its speed, such a computer, even if "down" a considerable percentage of the time, may have a much higher output than the best prewar mechanical computer working full time.

DR. JOHN H. CURTISS, who points out the changes mathematicians are effecting in the basic pattern of industry, is Chief of the National Applied Mathematics Laboratories of the Bureau of Standards. He has authored a number of papers on mathematics and is active in several societies.



SEAC, the Bureau's abbreviation for its electronic computer, combines a vast number of simple operations into a complex, high speed sequence by means of which it can calculate answers to many difficult problems.

Using Mathematics for Design,

COMPUTING MACHINES have received considerable attention in newspapers and general magazines in the past two years. Editors have had a field day speculating about machines that "think".

Do computers have a logical place in industry? What type of problems can they solve? When can they be used to best advantage? Should industry make greater use of mathematical specialists than in the past? Dr. J. H. Curtiss, head of the mathematical division of the National Bureau of Standards, has some definite ideas about these and other questions affecting the role of mathematics in industry—and showed no hesitancy in speaking on them when interviewed by PRODUCT ENGINEERING with a portable recorder.

PE—Isn't it true, Mr. Curtiss, that mathematics is playing an increasingly important role in industry?

CURTISS—Yes, applied mathematics is on the threshold of a really revolutionary development. Numerical answers to physical problems can now be obtained at hitherto undreamed of speeds by high speed computers. Moreover, over the last 20 years, there has been a phenomenal growth in the field of mathematical statistics.

PE—When you refer to mathematical statistics, do you have in mind statistical methods of quality control?

CURTISS—That among other applications. In simplest terms, mathematical statistics is the application of the theory of probabilities to practical problems, as for example, to production quality control problems. However, statistical methods can also be used in research and testing activities. In test and research, two analyses are required: a pre-analysis of experiments—sometimes called design of experiments—whereby the patterns and methods of collecting data are set up so that they will produce data that are valid and reliable; a post analysis of the data collected from the experiment, in which the data are processed, interpreted, and used as a basis for inferences. This insures that the greatest amount of information is obtained from any given test or experiment. Modern mathematical statistics provides highly useful mehods and tools for both these analyses.

PE—Besides its use in setting up inspection quality control procedures and other standards, mathematical statistics appears to find application in scientific development work. Isn't it true that some of these problems are so complex

LESS COMPLEX PROBLEMS—but problems which are still too large for manual computing methods—are presented to the IBM punch-card machines for solution. The newest is the 4 unit Card—Programmed Calculator to which instructions as well as numbers can be given. The machine is shown in operation at the computing center of NBS.

Research and Production

that mathematical specialists are needed to solve them—that interpretation of the problems is beyond the realm of the ordinary engineer in government or industry?

CURTISS—Yes, that's perfectly true. Certainly, an example of this is the growing complexity of war—of the methods of making war. The first World War has commonly been called the chemist's war. The second World War was the physicist's war. There are men who say that the third World War, if it occurs, will be the mathematician's war!

PE—Would you mind explaining this a little more fully?

CURTISS—Nearly all phases of the art of war present problems for the mathematician. For example, defense networks against attacking airplanes, and guided missiles, and many other modern weapons are based on theories of extreme complexity. Another example is the science of operational analysis which came into being in World War II. In this, data are analyzed using both mathematical and physical methods, and the conclusions reached form the basis for decisions as to both overall or immediate strategy, as the case may be.

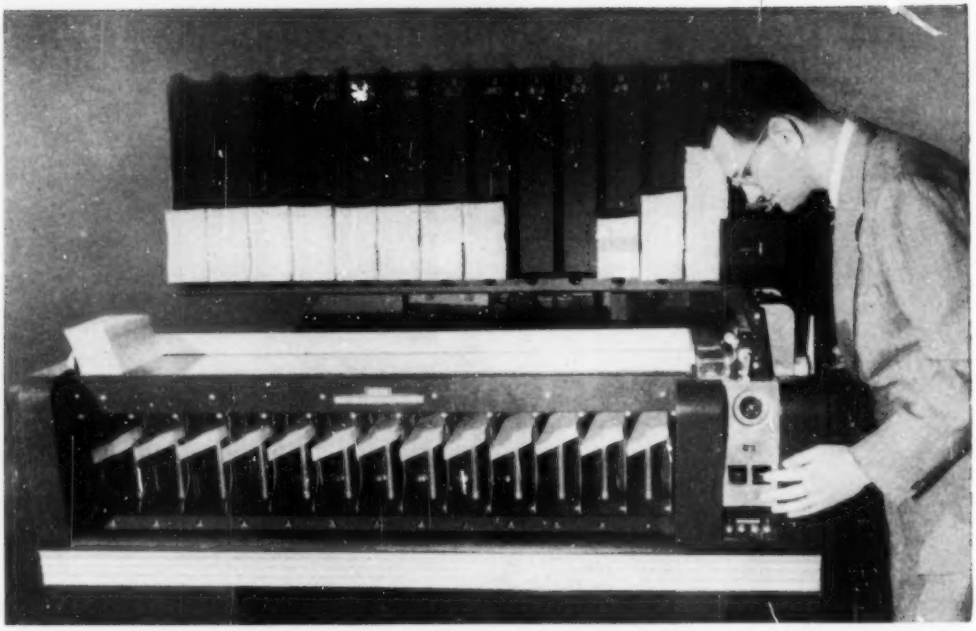
Computers Cannot Think For Themselves

PE—We have heard the expression made about computers, "Let's record everything in sight and the machine will do the rest." Would you care to comment on this?

CURTISS—Certainly a computer is a highly complex instrument, but even though it may be able to perform its intended function with great accuracy and precision, the truthworthiness of its answers depend upon the trustworthiness of the raw data themselves.

PE—Are we to infer from this then that you do not consider the computer a mechanical brain?

CURTISS—Right. Machines are stupid. Unlike a human computer, who can understand a variety of different orders given by another human being, the machine must have a problem very carefully and very adequately prepared, and the problem must be stated in the limited language understood by the machine. Even with a fully automatic computer, it is usually necessary to break down a problem into simple little routines. These limitations point up another problem, that of the need of re-writing large



ELECTRONIC SORTER is another new IBM machine. Cards punched to represent numerical data are sorted electronically before they are run through an IBM punched-card computer.

parts of mathematics, for the classical way of doing problems is not adequate for the newer computers, not even for the automatic types.

PE—The speed of the computer is, of course, the factor that is so much discussed today. Will you show us just how important this characteristic is?

CURTISS—Their enormous speed brings into the realm of possibility problems that, hitherto, have been impractical of solution by numerical methods. Such problems often present physical aspects which must be determined theoretically and by computation. Let us suppose, for instance, that a new type airplane is to be designed—one without wings. Needless to say, there would be a heavy mathematical analysis involved before this particular airplane would fly or even before it would be desirable to build a model. The research problem, of course, lies in how to set up the theoretical formulations that are derived so that they can be fed to the computer. Once this is done, the computing machine can determine the answers to problems that would otherwise take many man-years of labor to obtain. Sometimes the answer is gotten on a punch card machine, sometimes on an analogue computer, and sometimes on a large automatic digital machine. At any rate, the machine gives an answer that can be converted to a numerical quantity, whereas only a theoretical answer could previously be obtained.

PE—Do you not have several computing machines in the Computing Laboratory of the National Bureau of Standards?

CURTISS—Yes. Our objective, of course, is to provide computing services on high speed machines to other government agencies. Until recently, our largest machines have been IBM electronic punch card machines. Now in operation here in our laboratory, however, is a really high speed automatic computer which is called SEAC—Standards Eastern Automatic Computer. Another similar machine is being completed in the computing laboratory of the Institute of Numerical Analysis on the west coast. That computer is called the NBS Western Automatic Com puter, or SWAC for short.

PE—Have these new automatic machines, then, superseded the older ones?

CURTISS—Not at all. To cover the broad spectrum of problems that we are called upon to solve, we must have machines of intermediate size such as the IBM punch card machines as well as the large scale computer. Put another way, we try to use the machine that provides the most economical way of doing the job.

PE—It seems obvious that industry can benefit greatly from the work you have done here. However, just how can industry make use of that work? For example, will you contract to solve problems for them? Will you help them to devise the proper methods of attack if they install their own computers?

CURTISS—Taking your last question first, we are glad to assist private industry by advice and consultant services in setting up mathematical sections. The performance, however, of actual compution services for private industry on a large scale of pay cannot be done directly, for the law under which we operate is not set up that way.

PE—Haven't you performed a lot of computing work, though, for industry, particularly the aircraft industries and associated firms in southern California?

CURTISS—Yes, that's so. This has been done when a government agency contracting for the work done in those industries has sponsored the services we have performed.

Staff of a Mechanical Department For Industrial Companies

PE—So far our discussion has brought out the growing importance of the aid that mathematics is giving at the present time, and will continue to give to industry. Suppose then that a firm wishing to get in step with this trend decides to set up a mathematical section. How would it go about doing so?

CURTISS—My first recommendation is that the mathematical section be given the dignity of a separate organization, preferably at a staff level in the engineering department or research laboratory. The idea is that it should form an advisory group on the staff of, e.g., the director of the engineering division. It should never be part of the production department. Setting up the mathematical section in this way makes the most effective use of the contribution the mathematician can give to the firm. For one thing, the mathematician is more likely to be brought in at the planning stage of an investigation where decisions are made as to what data to collect and how to collect it. Since worthwhile conclusions can be drawn only from valid data, it can be seen how important this is. If the concept of the staff-level mathematics group seems impractical, then, at least, the mathematics group should be set up as a separate section in the engineering division or in the research laboratory.

PE—Then, what has been the place of the mathematician in industry?

CURTISS—Until recently, mathematicians working in industry have been sprinkled individually throughout the organization at rather low levels as assistants to engineers or production men. I do not suggest that such assistants are not needed, but I do wish to recommend that a more fundamental approach be used at the same time. The mathematical section when set up as a separate organization will act as an informal coordinator of research, drawing to the attention of workers in one branch related research completed, in progress, or contemplated in another —research, which, as it has been aptly put, "involves the same verbs but different nouns."

PE—If the firm already has an inspection quality control group, how should it be fitted into the organization picture?

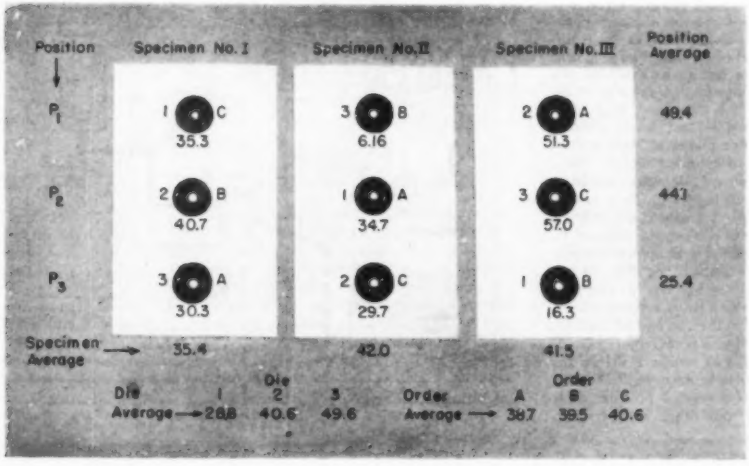
CURTISS—It is quite possible that it would be advantageous to consolidate it and the applied mathematics group as has been the aim here at the Bureau of Standards. This would, on one hand, tend to elevate the standards of statistical work—a worthwhile objective in that statistics have not always enjoyed a good reputation among scientists—and, on the other hand, the proximity of the two groups would make the mathematician more aware of the vital part probability plays nowadays in applied mathematics. This is important because applied mathematics makes increasing use of probabilities, for example, in the theories of noise in electronic circuits and in the study of radio propagation.

PE—We now have the organization, but how are we going to staff it?

CURTISS—An additional reason—and perhaps the most important one—for the consolidation of mathematical activities and their elevation to the dignity of a separate section is to be found in the difficulties inherent in recruiting competent applied mathematicians for the service of industry. Traditionally mathematicians have enjoyed not only the freedom of the academic atmosphere but the freedom to select their own problems. To work in an industrial organization on other people's problems is a novel experiment for them. Bell Telephone Laboratories is one of the few industries that has been outstandingly successful in gathering a group of competent mathematicians.

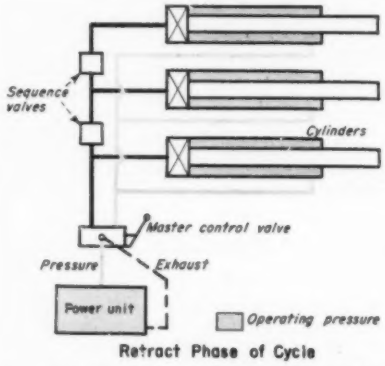
PE—Do you have any further recommendations to make or comments to add on this phase of subject?

CURTISS—Only this. I believe that all industries should explore the potentialities of the high speed computing machines not only as an aid in solving engineering problems but for their inventory, stock control and other financial and accounting operations. There is great activity now in adopting high speed electronic machines to the business administration type of problem. It is my feeling that any industry that is not cognizant of this is missing the boat.

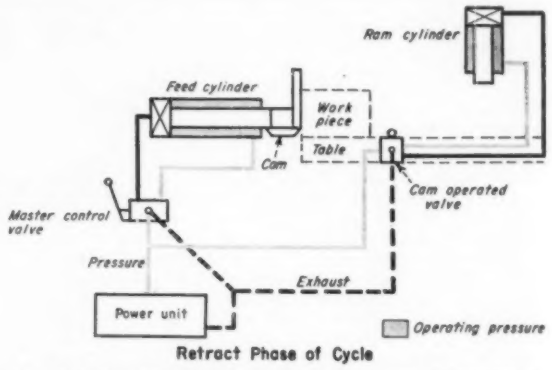


This 3 x 3 latin square is part of an experimental statistical investigation of the effect of deforming die depth on the apparent adherence of porcelain enamel to metal. Dies 1, 2 and 3 are progressively deeper by 0.020 in. A value of 169 represents 100 percent bare metal exposed. By means of this square, the number of variables affecting results can be isolated—here position, specimen, die, and order.

Sequential Operation of

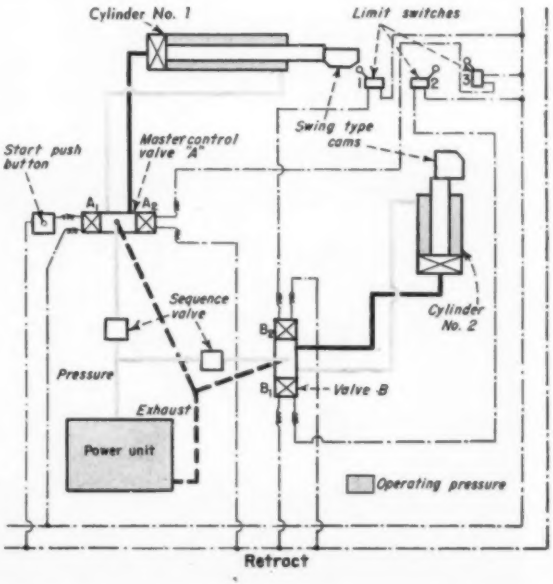


1. PRESSURE - OPERATED SEQUENCE VALVE. By the use of only one 4-way master control valve, a number of cylinders can be set up in sequence. To obtain the proper order of operation, each sequence valve is arranged so that as the pressure builds up when one cylinder completes its stroke, the valve will open and allow oil to flow to the next cylinder. This same occurrence is repeated throughout the entire cycle of cylinder operation. If the force in psi required for actuation of the first cylinder is greater than that for the second or third, sequence valves cannot be applied successfully.



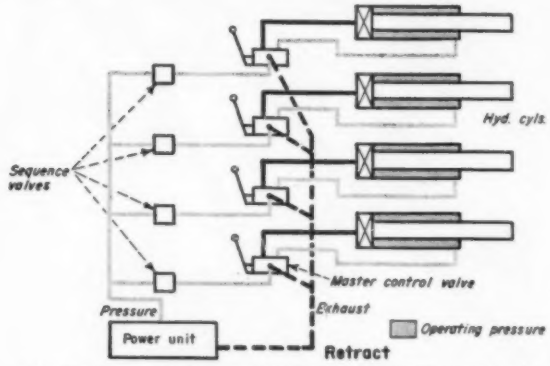
2. CAM-OPERATED SEQUENCE VALVE. This circuit uses a cam operated 4-way control valve to govern the sequence of cylinder actuation. In normal position both of the piston rods are retracted. With the operation of the 4-way master control valve, oil flows to the blind end of the feed cylinder. At the end of the feed cylinder stroke, the cam-operated valve is contacted and oil flows to the blind end of the ram cylinder, forcing the ram to the outer extremity. When the master valve is shifted again, oil flows to the rod end of the feed cylinder and the piston begins to retract. As the cam rides free of the roller of the cam-operated valve, oil is reversed in the ram cylinder. Since this circuit is controlled by two valves, the pressure required to move one cylinder is independent of the other.

5. ELECTRICAL CONTROL OF SEQUENCE. Electro-hydraulic controls are extensively used because of their speed and flexibility. Contributing to the latter characteristic are the facts that electrical circuits can be made as complex as desired and that the control units—pushbuttons, limit switches, interlock switches, etc.—can be located wherever convenient. In the circuit shown, solenoid A_1 of the 4-way master control valve A is energized by momentarily depressing the start push-button. This causes the valve piston to shift and directs oil to the blind end of cylinder No. 1. Then, the oil pressure forces the ram to its extended position. As the piston rod approaches the end of its stroke, limit switch No. 2 is contacted, thus energizing solenoid B_1 of the second 4-way control valve. This causes the valve piston to shift, admitting oil to the blind end of cylinder No. 2. Then, the ram of this cylinder moves out until the piston rod contacts the limit switch No. 3. As a result, solenoid A_2 of master valve A is energized, shifting the valve piston and directing oil to the rod end of cylinder No. 1. As the piston rod approaches the end of its return stroke, it contacts the roller of the limit switch No. 1. This switch acts to energize solenoid B_2 of the 4-way valve B. The valve piston shifts and oil is admitted to the rod end of cylinder No. 2. The ram of this cylinder is thereby retracted. In the sketch at the right, two sequence valves are employed in the manifold line. As described under Fig. 3, above, these valves prevent a pressure drop in either cylinder while the other is operating.

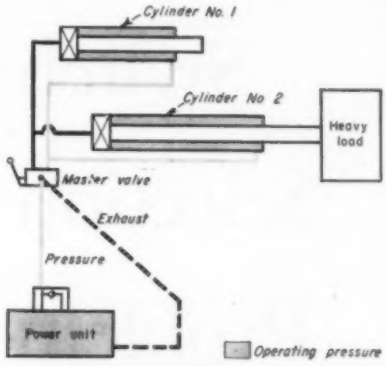


Hydraulic Cylinders

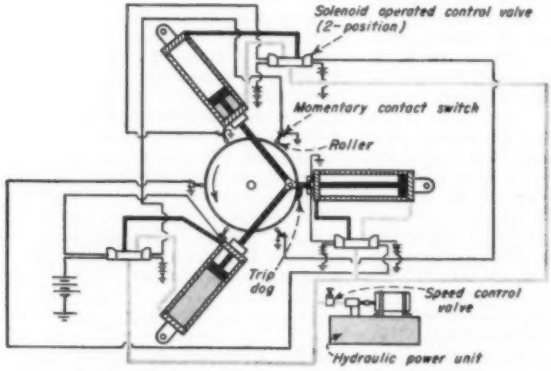
H. L. STEWART
Logansport Machine Co., Inc.



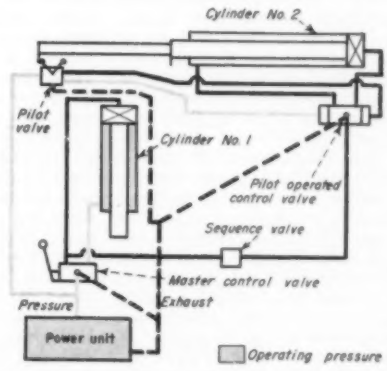
3. MANUAL CONTROL—CONSTANT PRESSURE. With this hydraulic circuit, any one cylinder of a group can be operated without causing a noticeable pressure drop in any of the other cylinders. A circuit of this type finds wide usage where one power unit is made to serve a number of cylinders. When there is full pressure in the feed line, all sequence valves are open. If the master control valve of any one of the cylinders is shifted, the resulting drop in line pressure causes the sequence valves leading to the other cylinders to close. Thus, oil under pressure is trapped in all cylinders with the exception of the one being operated. Were sequence valves not used, there would be a pressure drop in the remainder of the cylinders until the ram reached the end of its stroke.



4. MOVING DIFFERENT LOADS IN SEQUENCE. This circuit has been used to good advantage in sequential operation. This circuit makes use of a Hi-Lo pump which delivers high volume at low pressure and high pressure at low volume. This can be used on an installation where the No. 1 cylinder moves against slight resistance at a high speed and cylinder No. 2 must move out under low speed at a high pressure due to a heavy load. This eliminates a sequence valve and affords a very simple circuit. Cylinder No. 1 reaches the extent of its travel before cylinder No. 2 moves.

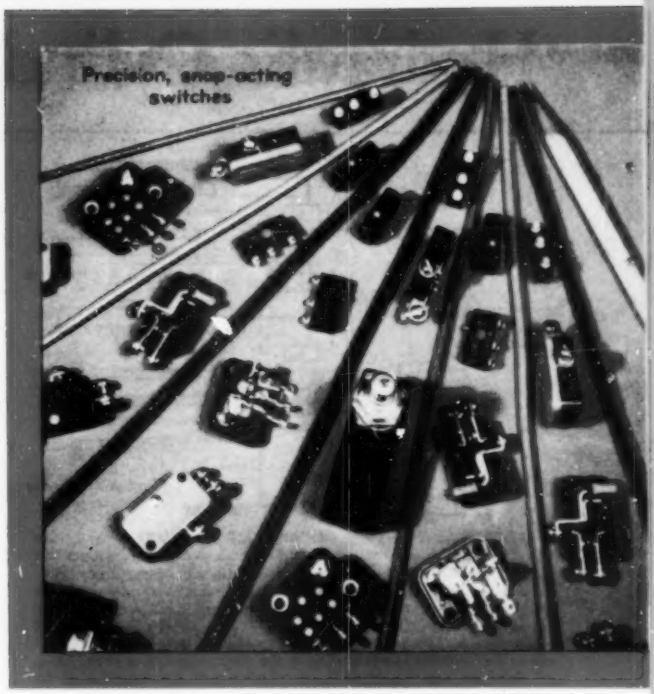


6. ROTARY MOTION. Solenoid valves control the operation of three cylinders in sequence for driving a flywheel. Each cylinder has pressure on the rod end for 180 deg of the flywheel cycle and pressure on the blind end for the 180 deg remaining. Two momentary contact switches, actuated by a trip dog on the rim of the flywheel, are wired to each of the control valves. When the switch directly opposite each cylinder is tripped, pressure is directed to the rod end of that cylinder. Tripping the adjacent switch reverses the control valve. Note that the cylinders are mounted at one end only and that this mounting is a pivot bearing. Thus, cylinders are free to oscillate, as is required by the rotating flywheel. Hydraulic lines must be flexible to accommodate the movements of the cylinders.



7. SEQUENTIAL OPERATION OF A RECIPROCATING PISTON. This hydraulic circuit makes use of manual and pilot operated valves to set up sequence operation. When the handle of the 4-way master control valve is shifted, oil flows to the blind end of cylinder No. 1. Ram of this cylinder moves to the outer end of its stroke. Pressure builds up, opening the sequence valve, allowing oil to flow to the pilot operated 4-way control valve. By pilot valve and trip dogs on piston rod, cylinder No. 2 automatically reciprocates until master valve is shifted and ram of No. 1 retracts.

Your Next Switch Selection Problem



A. L. RICHE
Vice President, Micro Switch Division
Minneapolis-Honeywell Regulator Company

PRECISION, SNAP-ACTING SWITCHES differ from the ordinary toggle types in that the operating motion required is measured in thousandths of an inch rather than by as much as ¼ in. or more. But because of precision methods of manufacture, particularly the holding of close tolerances during assembly and the use of beryllium copper spring members and silver contacts, such switches often are rated at capacities equal to or greater than the load ratings for larger conventional units. As a result, they are used not only for control but for power circuits as well. Examples of such uses are for thermostatic and pressure controls; limits and interlocks; safety stops; automatic cycle control; and counting, sorting, and weighing.

The variety of basic switches and their combination with actuators and housings has grown with their uses until several thousand combinations are available. Catalogs of manufacturers of course give detailed information on the characteristics of the various types of switches and the services to which they are best suited, but a review of the principal factors affecting selection and application, Table I, will contribute to improved performance, reduced cost, or both.

With few exceptions, noble metal, butt contacts driven by blade type, snap-acting mechanisms are used in switches of this type. They may be factory adjusted for self-returning action or to remain in either position until positively driven to the other. The action of this latter arrangement is referred to as "sustained contact operation".

Spring members are usually made of heat-treated beryllium copper, because of its good fatigue endurance and electrical conductivity. It performs well in continuous temperatures up to 250 F. However, for service above that temperature, other spring materials such as Duranickel, Ni-Span *C*, or Elgiloy can be used.

Contacts of fine silver are standard in this type of switch. Special alloys of silver, containing copper, nickel, iron, or cadmium oxide, have, however, been found to be superior to pure silver on certain loads where transfer of contact material is troublesome or where deposits of vaporized contact material invite dielectric breakdown. The selection of special contact material usually requires tests made under the conditions of the proposed use.

Cases of typical basic switches are molded from thermosetting plastics. General purpose phenolic is the most commonly used. Special materials are required for exposure to temperatures above 180 F.

Metal housings may be necessary when the switch is exposed to the entrance of oil, coolant, or fine dust or is subject to mechanical impact and shock. Most of them are die castings. Where sealing is required they can be equipped with gasketed covers and synthetic rubber boots on operating plungers. Special pressure seals and ice scraper rings should be specified if operating conditions require such protection. Explosion-proof housings that meet Underwriter requirements also can be obtained.

Actuation and Operation

A few types of basic switches and housing assemblies are operated by rotary motion through suitable crank arms. In the more usual linearly actuated form, the switch spring is snapped from one position to the other by movement of a plunger, through a distance which varies from 0.0002 to 0.005 in., depending on the type of switch. Overtravel of the operating plungers of basic switches beyond the point of switch operation is seldom greater than 0.020 inch.

Small actuating motion is often use-

TABLE I — FOURTEEN CHECK POINTS FOR SWITCH SELECTION

1. Circuit Required:
   - Single pole, single throw
   - Single pole, double throw
   - Double pole, single throw
   - Double pole, double throw
   - Split contact
2. Type of Operation:
   - Self-returning
   - Maintained contact
   - Make-before-break
3. Electrical Load:
   - a-c or d-c
   - Volts
   - Resistive
   - Inductive
   - Lamp
   - Inrush amperes
   - Steady state amperes
   - Power factor
4. Ambient Temperature.
5. Exposure to:
   - Humidity
   - Oil vapor
   - Liquid splash
   - Immersion
   - Corrosive atmosphere
   - Explosive atmosphere
6. Life Required:
   - Minimum acceptable number of operations, mechanical.
   - Minimum acceptable number of operations, electrical
   - Will failure to make or break circuit as ultimate mechanical life is approached be disastrous?
7. Frequency of Operation
8. Repeatability Required:
   - Permissible deviation from nominal point of actuation.
9. Exposure to Vibration or Impact:
   - Is vibration synchronous with load frequency?
10. Operating Force Available.
11. Operating Motion Available.
12. Overtravel Required.
13. Nature of Operating Motion:
    - Cam
    - Linear
    - Tilting
14. Rate of Actuating Motion:
    - Micro motion
    - Intermediate motion
    - Impact motion

ful, as in gaging operations or precision limit stop work, but is unsuitable where the driving motion cannot be closely controlled. Several types of mechanisms are used to link wide operating motion to basic switches. Such actuators may be built integrally with, or as attachments for, either basic switches or housings.

Switches snap from the normal to the operated condition in from 0.003 to 0.005 sec depending on the type of unit. On certain types of switches contacts on small electrical loads will follow mechanical operations up to 1,800 per minute. On full rated electrical load, heating by the arc limits the continuous rate of 150 operations per minute.

The ability to consistently repeat operation at a precise point in motion of the actuator over a large number of operations is, of course, an outstanding characteristic of precision, snap-acting switches. Certain units which are provided with wear-resisting guides and other special construction will repeat operation with a variation of plunger position no greater than 0.0001 in. over 100,000 operations without compensation for ordinary room temperature variations. The ordinary types of switch have repeatability on the order of 0.0005 in. under small electrical load, which may increase to 0.005 in. under maximum electrical load.

However, there are two often misunderstood points regarding repeatability:

1. Repeatability is independent of small operating motion. A switch which can be snapped from one position to the other by a motion of 0.002 in. may have even superior repeatability to one requiring a differential operating motion of only 0.0002 inch.

2. Close repeatability can be secured only on small electrical loads, usually no greater than 0.1 ampere.

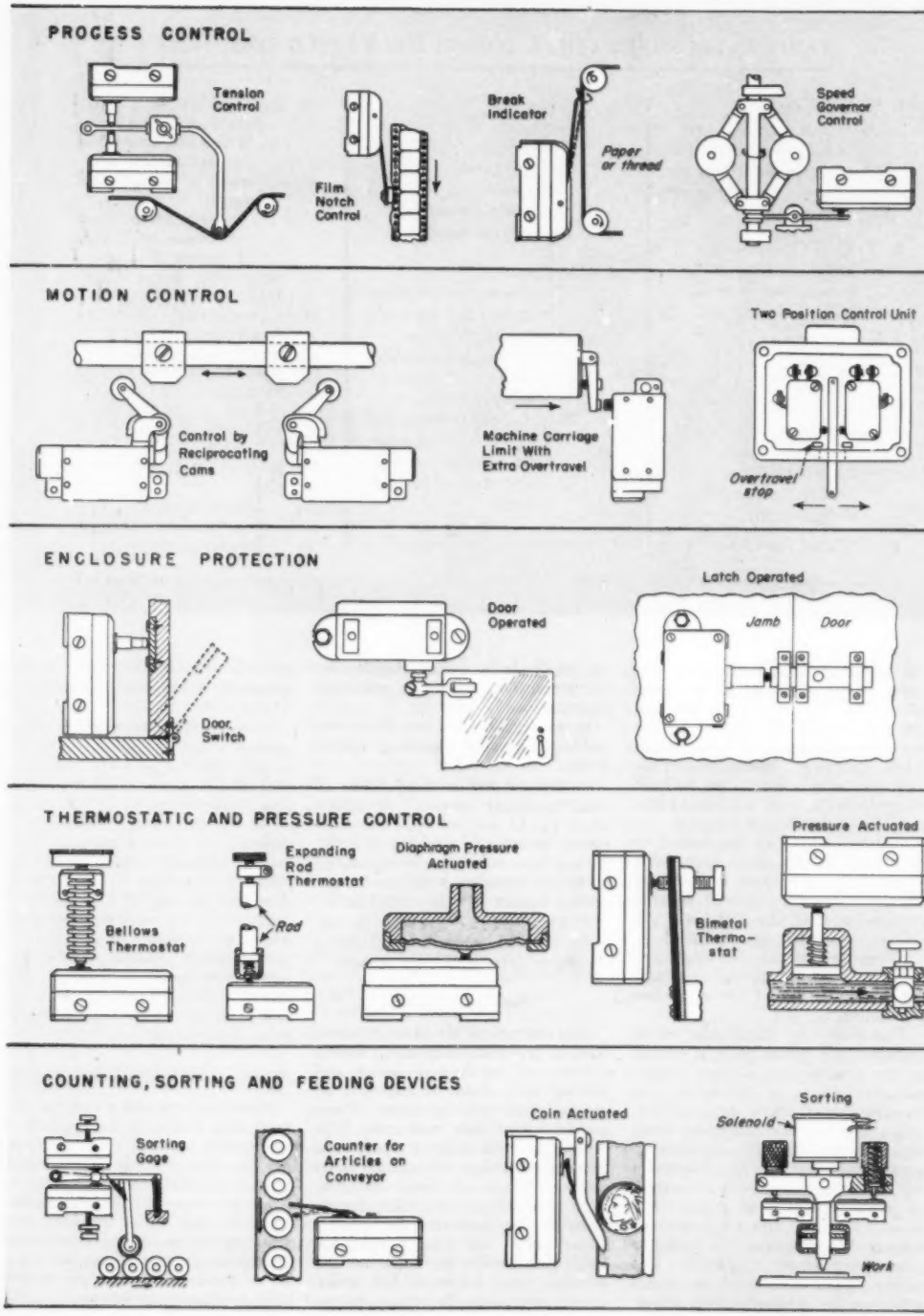
Anticipated Life

The mechanical life to be expected from a precision, snap-acting switch depends on the type of switch and whether it is driven to the limit of its stroke at each operation. There are laboratory tests and many field experiences with switches which have operated more than 150 million times without failure on small electrical loads at less than full stroke. Spring materials are, however, not entirely homogeneous, and data on probable switch life usually are based on the switches being driven to full stroke at each operation. For these reasons, probable life above twenty million operations is not usually predicted in catalog data.

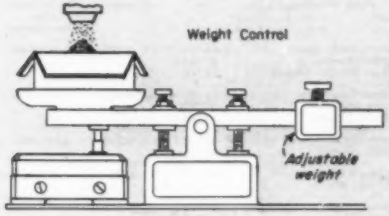
Under full rated electrical load, contacts usually reach full useful life in less than the probable mechanical life of the spring system. In many cases, however, probable contact life up to ten million operations may be expected. It must be borne in mind that as ultimate contact life is approached there may be occasional intermittent sticking of contacts which dictates that on critical applications, where no failures can be tolerated, routine switch replacement after suitable service should be practiced. The cost of such replacement is often less than even brief down time for emergency replacement.

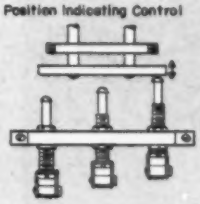
Resistance to Vibration and Impact

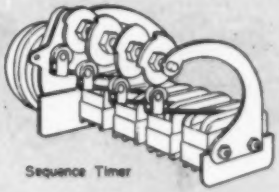
Precision, snap-acting switches perform satisfactorily in the presence of acceleration varying from 20 G to 600 G. The effect of acceleration is greatest when the switch is near the point of snapover. For this reason, vibration may cause trouble when actuating motion is slow and never departs far from the snapover point, as in thermostats. In uses of this kind, satisfactory performance is often

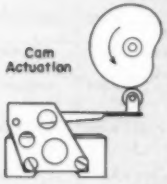

PROCESS CONTROL
Tension Control
Film Notch Control
Break Indicator
Paper or thread
Speed Governor Control
MOTION CONTROL
Control by Reciprocating Cams
Machine Carriage Limit With Extra Overtravel
Two Position Control Unit
Overtravel stop
ENCLOSURE PROTECTION
Door, Switch
Door Operated
Latch Operated
Jamb
Door
THERMOSTATIC AND PRESSURE CONTROL
Bellows Thermostat
Expanding Rod Thermostat
Rod
Diaphragm Pressure Actuated
Bimetal Thermo-stat
Pressure Actuated
COUNTING, SORTING AND FEEDING DEVICES
Sorting Gage
Counter for Articles on Conveyor
Coin Actuated
Sorting
Solenoid
Work

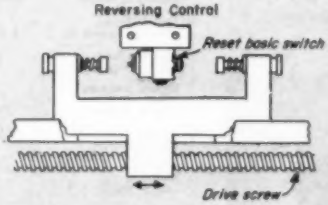
Application of Precision Snap-Acting Switches

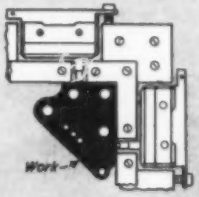


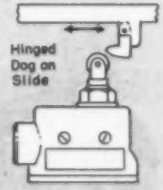




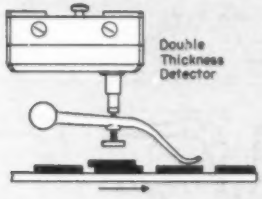


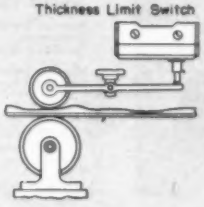


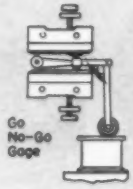


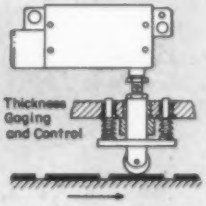


GAGING AND THICKNESS CONTROL

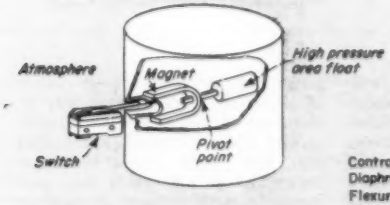


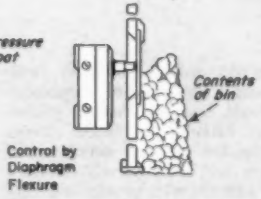


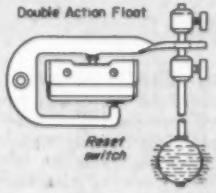




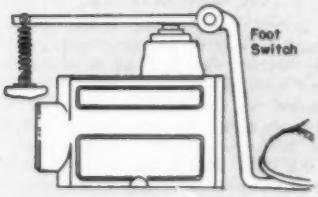
LEVEL CONTROL

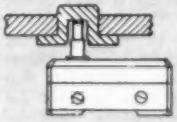


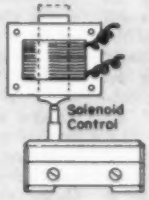


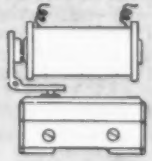


MISCELLANEOUS









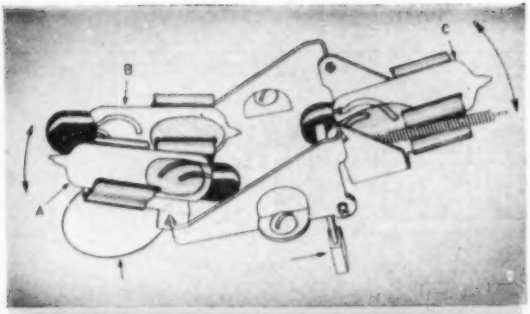


Fig. 1—Mercury switches for automatic washing machine. Switch A starts motor, switch B stops fill valve, switch C, mounted on cover, is tilted to provide safety stop of motor when cover is raised or if drying load is unbalanced.

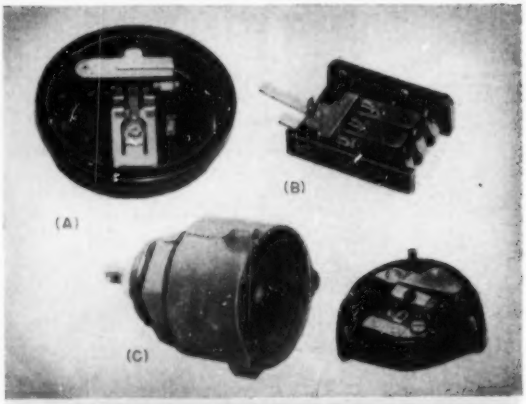
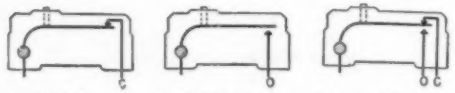


Fig. 2—Special-use switches for: (A) washing machine level control; (B) gang controls for coin-operated devices; (C) automobile automatic gear shift controls.

Table III—Mechanical and

Switch Type (Cat. Number)	Size, in.	Weight, lb	Probable Mechanical Life (Operations)	Contact Arrangement (See notes)
Conventional Case Highest Precision (BZ-R, BZ-2R, Micro)	1-15/16× 27/32× 11/16	0.049	20,000,000	1, 2, 3
Conventional Case Heavy Duty (BA-2R, Micro)	1-15/16× 27/32× 11/16	0.050	10,000,000	1, 2, 3
Hermetically Sealed (1HS1, Micro)	1-15/16× 1-1/8×11/16	0.094	2,000,000	3
Magnetic Blowout (MT-4R, Micro)	1-15/16× 7/8×11/16	0.061	800,000	3
Subminiature (1SM1, Micro)	25/32× 1/2×1/4	0.004	44,000	3
Miniac (Acro)	1-13/64× 53/64×9/32	0.014	3,000,000	3
Split Contact (BZ-3YT, Micro)	1-15/16× 1-1/16×11/16	0.065	300,000	5
Double Break (AO-1A, Square D)	53/64× 1-1/32×2-1/2	0.088	10,000,000	5 & 5A
Medium Size (V3-1, Micro)	1-3/8×1× 13/32	0.017	50,000	3
Rotary Actuated Sensitive (V4-14, Micro)	1-1/16× 1-3/64× 3/4	0.016	4,000,000	1, 2, 3
Double Pole Double Throw (DT-2R-A7, Micro)	1-15/16× 1-1/4× 11/16	0.066	350,000	4
Skeleton (SK-3, Micro)	2-1/8× 7/16×7/16	0.010	10,000,000	1, 2, 3
Mercury Switch, Small (AS408D1, Honeywell)	1-7/16× 11/32	0.012	varies with care given leads	6
Mercury Switch Medium S.T. (AS454A1, Honeywell)	2-7/16× 37/64	0.050		6
Mercury Switch Medium D.T. (AS628C1, Honeywell)	3-1/8× 17/32	0.044		7
Mercury Switch, Large (AS482A1, Honeywell)	2-3/16× 41/64	0.169		8



1. Single Pole, Normally Closed. 2. Single Pole, Normally Open. 3. Single Pole, Double Throw.

9. 30A for N.C. contact, 15A N.O. contact.
10. 5A for N.C. contact, 2.5A N.O. contact.

secured by so mounting the switch that the plane of the spring will be parallel to the direction of acceleration or by providing isolating resilience in the mounting. This can be important if the source of vibration is a motor, or motor-driven fan, supplied from a source synchronous with the power being switched, for under critical conditions such vibration can cause the switch contacts to open and close circuit on alternate halves of the cycle, with resulting contact damage. Special vibration-resistant switch designs are available for use when conditions are particularly severe.

Electrical Capacity

The alternating current power which can be reliably controlled at rated life often seems out of proportion to the small size of many precision, snap-acting switches. Experience has shown, however, that the Underwriters' Laboratories' listed ratings recommended by most switch manufacturers are conservative. At rated loads, difficulty with prompt interruption of a-c loads is unknown under ground level operating conditions. Temperature rise is seldom important, except when caused by heating of the arc on maintained high speed operation on heavy loads.

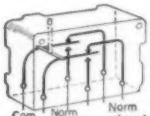
The limit of rating is fixed by the ability of a switch to close circuit without sticking or welding of the contacts to an extent which prevents reopening. It is for this reason that only certain types of switches are Underwriters' Laboratories' rated for control of tungsten lamps where the instantaneous current flow at closure of circuit on a cold filament may be more than ten times the hot filament current values. Solenoids and motors also permit high current inrush on closure of circuit, which may permanently weld contacts of switches that are not particularly suited to such service.

Use on Direct Current

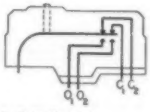
Several styles of the simple mechanical types of precision, snap-acting switches serve well on direct current loads up to 30 v, but all are limited in the Underwriters' Laboratories rating which can be secured for service on 115 v or higher (see Table III). This is due to the small contact separation failing to interrupt the arc, particularly on inductive loads.

Electrical Characteristics of Typical Switches

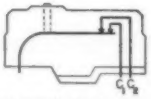
Operating Force, oz.	Differential Travel, in.	Resistance to Acceleration (centrifuga. (gravity units) switch unoperated	Alternating Current Ratings				
			Voltage, volts a-c	Inrush Current, amp.	Steady State Current, amp.	Lamp Load amp.	Motor Load, HP
7 to 13	0.0002 to 0.002	40	440	30[11]	15	5[11]	1/4[11]
11 to 22	0.002 to 0.0075	190	440	75	20	10	3/4 at 115V 1-1/2 at 230V
10 to 22	0.020 max.	95	125 (30Vd-c)	— (70)	1 (25)	— (5)	—
10 to 15	0.005 max.	—	(125Vd-c)	(30)[12]	(10)[12]		(1/2 at 115Vd-c)
7 max.	0.008 max.	over 600	250	12	5	—	1/8 at 230V
3 to 20	0.007 to 0.015	over 15	125	50	10	6	—
16 to 26	0.001 to 0.004	90	250	15	5	—	1/8 at 115V 1/4 at 230V
10 to 14	0.035 to 0.046	—	110 to 600	40 to 8[13]	15 to 5[13]	—	1/2 at 110-220V
6 to 14	0.006 to 0.016	—	250	35	10	—	1/3 at 115V 3/4 at 230V
4 gram-in. max.	12° max.	—	250	—	5	—	—
20 max.	0.035 to 0.055	72	250	30	10	—	1/4 at 115V 3/4 at 230V
3 to 8	0.008 to 0.030	—	250	35	5	—	1/4 at 115V 3/4 at 230V
varies with application	12°	varies with application	250	—	1	1	—
	5°		250	45	10	10	1/2
	1°		250	13	5	5	1/12
	6.5°		250	144	45	20	3



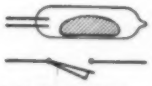
4. Double Pole, Double Throw.



5. Split Contact.



5A. Double Break.



6. Metal to Mercury, Single Throw.

7. Metal to Mercury, Double Throw.

8. Mercury to Mercury, Single Throw.

11. 1/4 HP N. C. contact, 1/8 HP N.O. contact.
12. Resistance load ratings
13. Current rating dependent on voltage.

Inductive loads are not only difficult to interrupt, but switch performance is often impossible to predict except by tests. On many installations, however, satisfactory performance on substantial loads can be secured by various condenser and resistor combinations which reduce the arc and lessen the transfer of contact materials which tends to close the separation between contacts. Rectifiers are also used to assist in arc-interruption. Manufacturers' catalogs give some data on protective networks, but the experience of their engineering departments is often needed, as this problem is seldom simple.

Direct current motor running loads of relatively high value can be interrupted without the use of arc-controlling networks because of the small potential appearing at the switch.

Control of direct current loads up to 10 amp at 115 v without the use of condensers, is provided by basic switches containing permanent magnets which put out the arcs. Most such switches must be polarized; that is, the plus connection made to the indicated terminal only in order that the blowout magnet may be effective. One such switch is, however, available in single pole, double throw construction which need not be polarized. This switch is also interchangeable in size with similar basic switches of conventional design.

Mercury Switches

A mercury switch consists of an insulating tube, usually glass, which is provided with two or more electrodes so positioned that as the tube is tilted from one position to another, mercury which partially fills the tube will close and open circuit between the electrodes. Outside connections to the electrodes are made through flexible leads. In many cases the tube is filled with hydrogen under pressure, which gives high interrupting capacity on direct current without the use of condenser networks. Fig. 1 shows use.

Besides these and the basic switches previously discussed, special switches —consisting of special assemblies of standard parts or representing completely new designs—sometimes are justified when volume required is sufficiently high to pay for tooling and engineering development costs. Fig. 2 illustrates several such special switches.

Further Examples of Calculating

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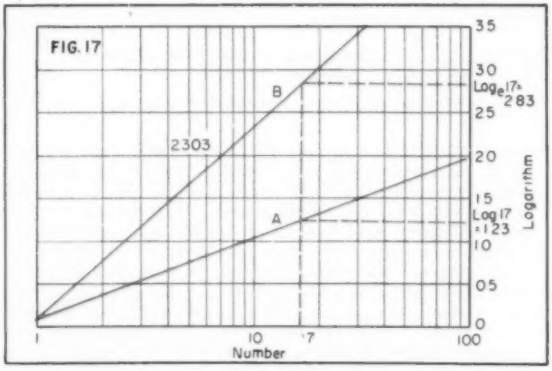
12 GEOMETRIC SERIES-SEMILOGARITHMIC PAPER. In a previous article (PRODUCT ENGINEERING, April 1951, page 140), the author discussed 11 methods of calculating with graph papers. In section 10 of that article, it was shown that a line segment whose terminal points are ordinates a and c has as its midpoint a point whose ordinate is the geometric mean of a and c; i.e., a number b, such that $a:b = b:c$. The length of the line-segment is, of course, immaterial. Consequently, if a straight line is drawn across the face of a semilogarithmic chart, its points of intersection with the abscissa lines will be a series of points whose ordinates have the relationship, $a:b = b:c = c:d = \ldots$. Such a series is known as a geometric series. Each term in this series is obtained from the preceding term by multiplication by a constant ratio. The numbers $\frac{1}{9}$, $\frac{1}{3}$, 1, 3, 9, 27, ... make up such a series, the ratio 3 being the common factor. Refer again to Fig. 14 of the April article.

13 PREFERRED NUMBERS—SEMILOGARITHMIC PAPER. Means of reducing manufacturing costs and simplifying maintenance procedures are continual design objectives. For example, it is desirable in designing a series of parts which are identical except for size, to select a size distribution which will provide the greatest possible flexibility in application, while keeping the number of such sizes to a minimum. It has been found that the optimum distribution is that in which the sizes correspond approximately to a geometric series. There are two conditions to be met in deciding upon such a series. First, there are approximate upper and lower limits for the sizes in the series. Second, it is usually desirable to have some of the sizes correspond to sizes of similar parts already in use or available from commercial stock.

A typical problem is one in which the designer wishes to establish a series of sizes for a roller of a type presently being used in a medium duty machine. The present machine utilizes rollers of this type in the sizes 4 in., 8 in. and 15 in. This particular machine has seen only limited production up to the present time. The executives of the company foresee that a profitable move would be to expand the market by making several different sizes of the same design, ranging from light to heavy duty. It is now desirable

14 LOGARITHMS—SEMILOGRITHMIC PAPER. In Section 7 of his preceding article, the author described a method for establishing proportionality with linear paper. This involved merely the drawing of vertical and horizontal lines to represent the numbers and a line from the origin to represent the desired ratio. Each pair of lines (an ordinate and an abscissa) whose point of intersection falls on the diagonal line from the origin has the same ratio. This method could be used for selecting combinations of stock gear sizes for a desired speed reduction. The greatest value of these techniques lies in practical applications. A similar procedure is conveniently applied to semilogarithmic paper to determine the values of logarithms of numbers to any base. Diagonals can be set up for a particular base if the logarithms of any two numbers to that base are known. Fortunately, the logarithm of the number one to any base is zero. Thus, if the scales of semilogarithmic paper are laid out as shown in Fig. 17, all diagonals will pass through the origin. To locate a diagonal only one other point is required. Diagonal B in Fig. 17 is established by using the well known value of $\log_e 10$, which is 2.303. To find $\log_e$



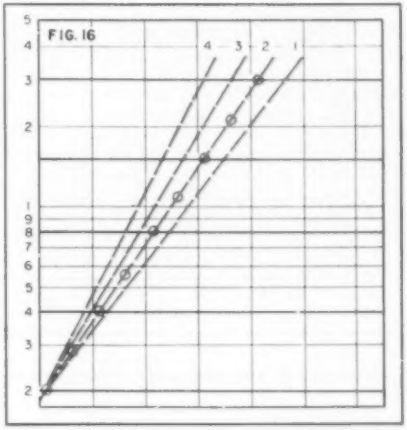
of any number, (take the number 17, for example), simply locate that number on the bottom scale. Erect a perpendicular at that point. Draw a horizontal line from the intersection of the perpendicular with the diagonal to the right hand scale and read the value of the logarithm directly. Diagonal A is set up similarly for $\log_{10}$ of any number.

Visualization and interpolation are the common uses of graph paper. An interesting deviation from these applications is the employment of graph paper in routine calculations of a nature frequently performed with slide rules or nomographs. Second of two articles.

With Graph Paper

to extend the limits of the available roller sizes to approximately 2 in. minimum and 30 in. maximum. Also, it is decided to provide at least one size between each two of the present sizes, but to limit the total number of sizes to ten at the most.

Referring to Fig. 16, the approximate upper and lower limits and the sizes now in production are represented by abscissa lines on a face of semilogarithmic graph paper. Trial index lines are now laid diagonally across the paper so as to intersect simultaneously these horizontal lines and several of the vertical ordinate lines, the purpose being to locate that diagonal which will intersect most of the abscissa lines closest to the evenly spaced ordinate lines. In this case, the diagonal which most nearly achieves this objective is line number *2*. This line intersects nine ordinate lines between and including the upper and lower limit abscissa lines, indicating that the optimum distribution includes nine, rather than ten, sizes. These sizes may be read as the ordinates of the points of intersection of the diagonal with the ordinate lines, and are approximately 2, $2\frac{3}{4}$, 4, $5\frac{1}{2}$, 8, 11, 15, 21, and 30 in. Exact readings are not required, since it is desirable to round these sizes off to standard fractions or to the particular sizes of items that are already carried in stock.

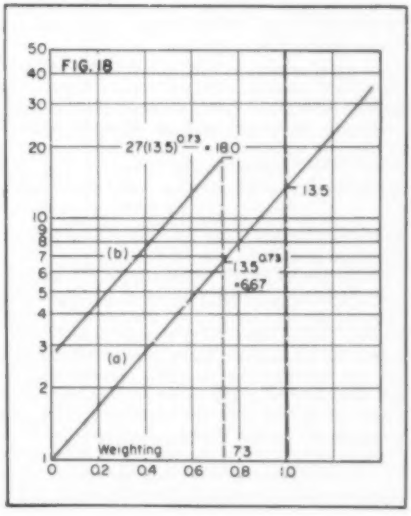


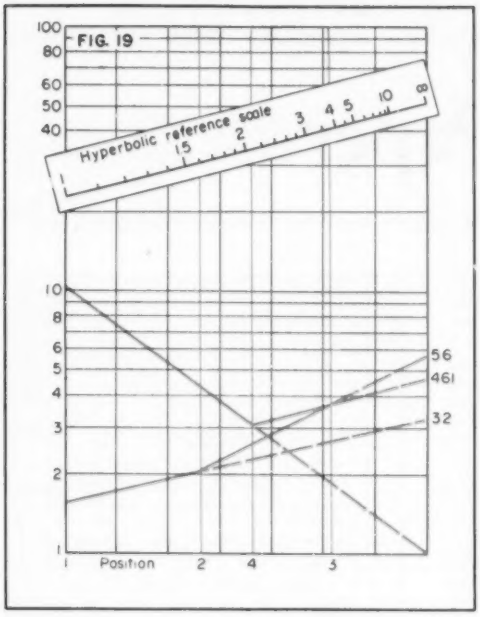
15 FRACTIONAL POWERS OF NUMBERS—SEMILOGARITHMIC PAPER. If y, m, and b are measured along the Y-axis, which is logarithmic, the straight line equation becomes $\log y = x \log m + \log b$ or $y = b \times m^x$. The magnitude of y can be determined graphically, as demonstrated in Fig. 18. Values of the variable exponent x are marked on the bottom scale. Values of m are found on the vertical line at $x = 1$ and a diagonal drawn from that point to the origin. For all points on diagonal (a) the value of the constant b is unity. For other values of the constant, a diagonal such as (b) is constructed.

16 PRODUCTS OF TERMS WITH FRACTIONAL POWERS—SEMILOGARITHMIC PAPER. Products involving one or more terms with fractional powers are frequently encountered in engineering fields. Taylor's equation for the pressure on a tool when cutting cast iron, $P = CD^{14/15}F^{3/4} = CD^{0.934}F^{0.75}$ might be cited, as well as several formulas for end thrust and torque of twist drills, of which an example is $P = 35{,}500\ d^{0.7}f^{0.75}$.

The general expression for this type of problem is $S = N_1^{w1}N_2^{w2} \ldots N_n^{wn}$, which is expressed logarithmically as $\log S = w_1 \log N_1 + w_2 \log N_2 + \ldots w_n \log N_n$.

This is recognized as a weighted sum of logarithms. Thus, the method employed for weighted sums in Section 5 of the preceding





article is conveniently applied to the computation of products involving fractional powers.

Unfortunately, a graph paper having logarithmic ordinates and hyperbolic abscissas is not available commercially. However, as shown in Fig. 19, the necessary vertical lines may be easily ruled onto semilogarithmic paper by reference to an hyperbolic scale. If the chart is to be used for a specific formula, it is unnecessary to rule vertical lines for any except the positions required by that formula. This was done in the accompanying illustration. However, if the chart is to be applied in general, it will be necessary to have vertical rulings corresponding to all the points on the hyperbolic scale. In this case, it probably would be advisable to paste logarithmic scales over the N_1 and N_2 scales of a piece of hyperbolic graph paper.

The graph in Fig. 19 is constructed for solution of the formula $x = 1.57\, a^{0.61} b^{2.2} c^{1.7}$, with the first number being located on the left-hand border scale, remaining terms being located on the right-hand border scale. The positions on which the index line is pivoted at the conclusion of each step in the computation are determined as follows:

Position 1 = 1st exponent (that of the constant term) = 1.00

Position 2 = 1st exponent + 2nd exponent = 1.00 + 0.61 = 1.61.

Positions 3 and 4 are determined by continuing this process and have the values 3.81 and 2.11, respectively. Figure 19 shows solution of this equation for the values $a = 3.2$, $b = 5.6$ and $c = 4.61$. This method may be applied to terms with integral powers and simple products as well as to products of fractional power terms.

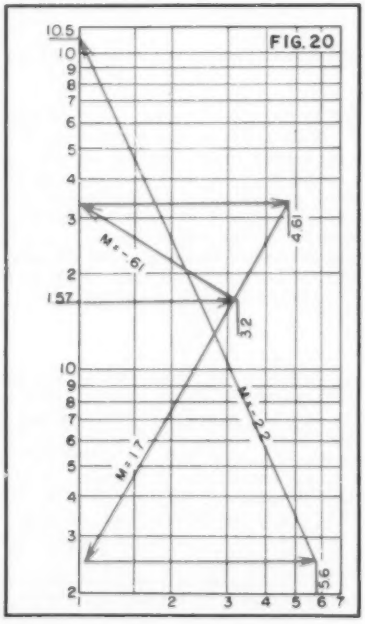
17 PRODUCTS OF FRACTIONAL POWER TERMS—LOGARITHMIC PAPER. FIRST METHOD. The method for products described in Section 11 of the previous article may be applied to products of fractional power terms by using slopes corresponding to the exponents. Since motion along the index line is towards the ordinate 1, the slope is the negative of the exponent. Division is indicated by negative exponents and, hence, by positive slopes. Multiplication is indicated by positive exponents and, hence, by negative slopes.

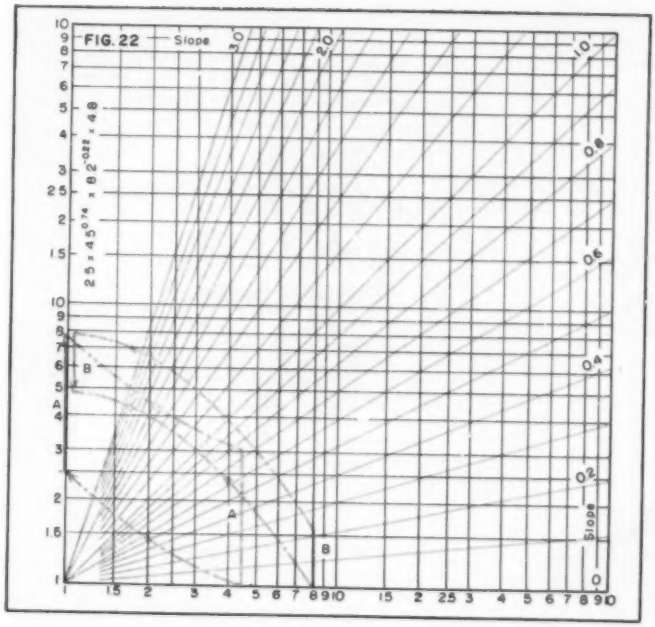
In applying this method, it is desirable to have at hand a card or other instrument marked with the various slopes. Such an instrument may be used with the T-square to obtain rapid evaluation of products. Or, if preferred, the slopes may be determined from a linear chart placed nearby and transferred to the logarithmic paper by the T-square-triangle method for drawing parallel lines. In Fig. 20, this method is applied to the solution of an equation. The values employed are:

$$x = (1.57)\ (3.2)^{0.61} \times (5.6)^{2.2} \times 4.61^{1.7}$$

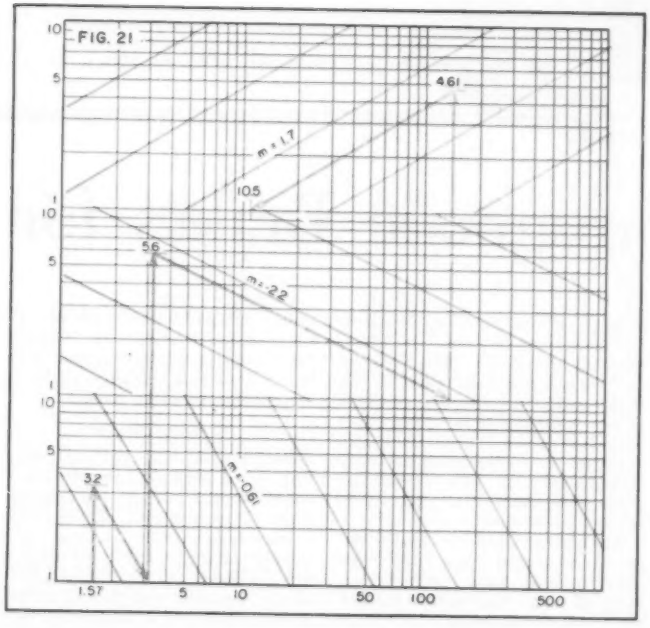
which is identical with the example in Section 16. The solution to this expression is 10.5, as before.

If the method is to be set up for the solution of a specific formula, it is desirable to draw the slopes corresponding to exponents directly onto the graph paper, rather than resorting to instruments or reference slopes. With these lines already available to represent the constant exponents the formula can be quickly solved by means of the graph paper for any values of the variables. Several such slopes may be drawn on the same face of graph paper, or separately on adjacent faces of graph paper, as in Fig. 21. In constructing this chart, it was desirable to transpose the X- and Y-axes. Each term in the product is then projected from its own Y-axis to the abscissa of the next term in the adjacent face. The illustrative exercise worked out on the graph paper in Fig. 21 is identical with the problem given above for Fig. 20.



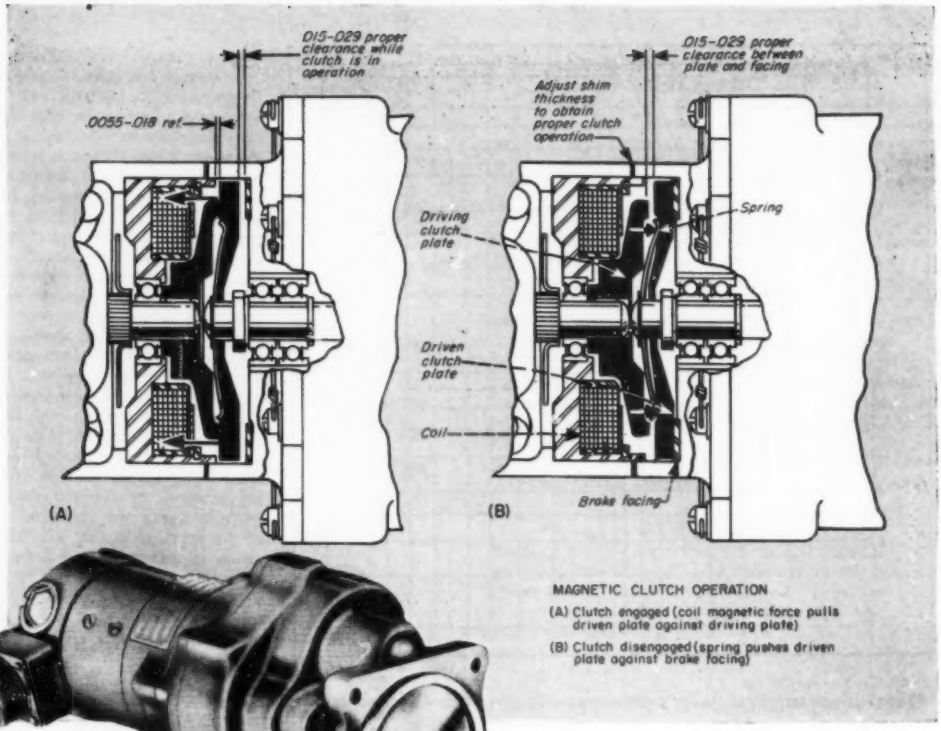


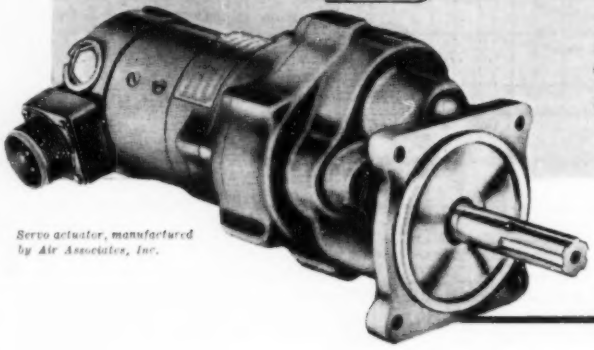
18 PRODUCTS OF FRACTIONAL POWER TERMS—LOGARITHMIC PAPER. SECOND METHOD. On standard graph paper, a straight line follows the equation $y = mx + b$. On log paper, a straight line is represented by $\log y = m \log x + \log b$; whence $y = b \times x^m$. In this method, lines of various slopes radiating from the origin are ruled onto the face of logarithmic paper. Since, at the origin, $b = 1$, the relationship realized by this family of lines is $y = x^m$. Evaluation of a fractional power term is then accomplished by locating the abscissa x and reading vertically to the corresponding value of m on the slopelines. Evaluation of products of such terms is accomplished by adding the line-segments thus determined. This may be done by use of dividers, each line-segment being placed with its origin on the terminus of the preceding line-segment along the left-hand border of the paper as in Fig. 22. Multiplication is indicated by a line-segment of positive sense; division, by a line-segment of negative sense. Constants may be introduced at any point in the computation.



CONCLUSIONS

Wher. the last described method is applied to a specific formula, only the slopes corresponding to the exponents need be drawn, and the method becomes a great deal more rapid. Indeed, it might be recalled that the feasibility of marking frequently used constants on graph paper to be used for calculations constitutes one of the desirable features of this device. This same fact applies to any of the graphical methods discussed in the two articles. Custom-made charts are feasible because the cost of setting up the graph paper is low. The time saving features of the graphical solution can be applied freely to individual problems and formulas.


.015-.029 proper clearance while clutch is in operation
.0055-.018 ref.
Driving clutch plate
Driven clutch plate
Coil
(A)
.015-.029 proper clearance between plate and facing
Adjust shim thickness to obtain proper clutch operation
Spring
(B)
Brake facing
MAGNETIC CLUTCH OPERATION
(A) Clutch engaged (coil magnetic force pulls driven plate against driving plate)
(B) Clutch disengaged (spring pushes driven plate against brake facing)



Servo actuator, manufactured by Air Associates, Inc.

GERALD KRONACHER

Electromagnetic Brakes for

THE POSITIONING ACCURACY of an open loop servo system depends greatly on the electromagnetic brake that is an essential component of all such systems. When responding to a signal, the positioning or servo motor operates under full power until the desired point is reached. Then, the signal is cut off abruptly and the brake applied.

A typical application of the open loop servo circuit is in the remote control of flaps in an airplane. The schematic in Fig. 1 depicts this system, employing a split series d-c servo motor. The direction of rotation of the motor is determined at the double-throw control switch. If the "a" terminal of the switch is contacted, the motor shaft turns clockwise, lowering the flaps. Energizing the "b" contacts results in raising of the flaps. Limit switches are provided to stop the motor at the extreme flap positions. When the circuit is de-energized by the opening of either control switch or limit switch, the brake coil within the motor shell releases the brake.

The aim of designers of such systems is to reduce motor speed from rated to zero within a minimum angle of coast. The latter is dependent on the overall design of the brake and motor. The choice of brake linings, type of electrical connections, spring pressure, motor dimensions and moment of inertia, all influence the accuracy of the servo system. The factor known as coasting angle is the criterion of brake design.

Coasting Angle

Behavior of the electromagnetic brake in the servo system can be anticipated by calculation of the coasting angle. This calculation is made with a reasonably simple formula, extremely useful in selecting or designing a suitable brake. Development of the equation also facilitates the understanding and evaluation of factors entering into brake performance. Therefore, it is presented here.

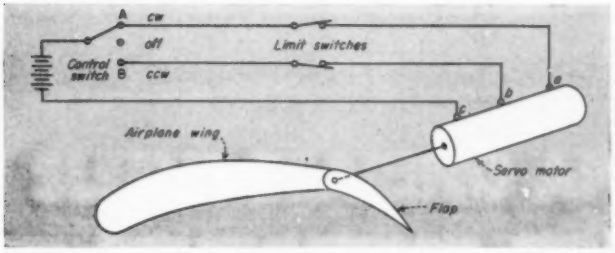


Fig. 1—Schematic drawing of open loop servo system for remote positioning of airplane wing flaps. Accuracy of flap settings depends largely on design of electromagnetic brake built into the servo motor. Flaps move up or down, depending on which motor field coil is energized. Limit switches prevent overtravel.

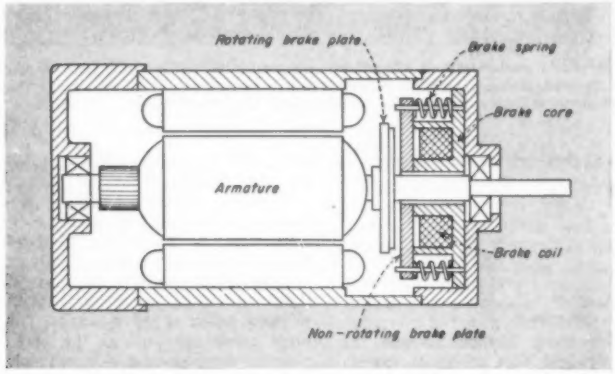


Fig. 2—Common arrangement of electromagnetic brake within motor shell. When coil is deenergized, springs push non-rotating brake plate against brake plate fixed to the armature. These compact motor-brake units are called "servo actuators" and are used in great numbers for remote control applications.

D-C Servo Motors

Following are the symbols employed:

α = coasting angle, radians
t = coasting time, sec
ω = angular speed, radians per sec
W = force or weight, lb
T = torque, ft-lb
m = mass in slugs (dimensions of mass are $\frac{lb \times sec^2}{ft}$)
D = diameter, ft
I = moment of inertia, slug-ft²

The simplified drawing, Fig. 2 shows a conventional arrangement of motor and brake. While the motor is running, the non-rotating brake plate is held fast against the magnetic core. The instant the motor is deenergized, the magnetic flux in the brake core begins to decay. Within a definite time period, which shall be called tripping time (t_t), the magnetic pull decreases to the point where it is overcome by the opposing spring force. Then, the brake plates engage and the motor armature decelerates to standstill. The time required for deceleration is designated as t_e. The coasting angle is a function of time required for both tripping and deceleration.

Deceleration time is calculated from brake torque, the rotor moment of inertia and the angular speed of the rotor at the instant of brake engagement. Using the symbols given, expression for deceleration time is:

$$t_d = \frac{\omega_o I_R}{T_b} \quad (1)$$

The coasting angle is equal to the initial speed multiplied by the tripping time plus the average speed during deceleration (half the initial speed) multiplied by the deceleration time. This is expressed as

$$\alpha = \omega_o t_t + \frac{\omega_o^2 I_R}{2 T_b} \quad (2)$$

It is to be noted that load inertia is not considered. The reason this can be done is because ordinarily the servo motor is connected to the load through high ratio reduction gearing. If load inertia is large, it can be provided for by adding to the motor inertia the quotient of load inertia over the square of the ratio of the gearing. The latter factor is usually extremely high, with the result that load inertia has a negligible effect on coasting angle.

The utility of Eq (2) is greatly enhanced by the availability of the quantities for the various symbols. Brake performance can be appreciated in the design stage without the necessity of setting up the system and running tests.

Brake Torque

The brake torque is computed from the total spring force on the stationary brake plate, the friction coefficient of the brake lining and the mean radius of action of the friction forces. Because compactness is essential in many servos, the latter radius is usually of limited magnitude. Therefore, the servo designer must concentrate his efforts on the springs and linings to obtain the optimum braking.

In practice, the stationary brake plate is often of low carbon steel with a ground finish. The brake lining is either cork composition, bonded asbestos or sintered metal. Cork composition has an excellent coefficient of friction, 0.45 and higher. But it cannot be used if the braking surface is allowed to get hotter than 200 F, because at higher temperatures, the cork becomes brittle. There is also a danger that the two brake plates may become bound together by the resins released from the cork composition. Another limitation is unit surface pressure, which should be held to a maximum of 14 psi for cork composition.

Bonded asbestos has a coefficient of friction of about 0.3 and is suitable at temperatures as high as 500 F. Pressures of 150 psi are permissible.

Sintered bronze, with a coefficient

of friction of from 0.1 to 0.3, can withstand a 1,000 F temperature. The material is bonded directly to the copper-plated brake-plate. The application of sintered metal for brakes and clutches is comparatively new so that some experimentation may be required in selecting the best grade for a specific purpose. Chief advantage of this material is its heat conductivity and stability at high temperatures. But the high friction grades often show poor wear resistance. Therefore the life of the brake or clutch should be checked by experiments. Surface pressure up to 50 psi can be tolerated.

Moment of Inertia

Analytical methods for determining rotor moment of inertia are used rarely, if ever, because they are complex and because simple and accurate experimental techniques exist. The common method makes use of a torsion pendulum, consisting of a fine wire hung from the ceiling and a straight circular cylinder suspended at the end of the wire. The moment of inertia of this cylinder is calculated from the following formula:

$$I_c = \frac{WD^2}{257.39} \qquad (3)$$

The pendulum is set into oscillation and its period observed. Then, the cylinder is replaced by the rotor, which is set into motion and its period recorded. Rotor moment of inertia is found by the ratio

$$I_R = \frac{I_c \times t_R^2}{t_c^2}$$

where t_R = period of pendulum with rotor
t_c = period of pendulum with cylinder.

In this case, the armature must be removed from the motor to determine its moment of inertia. But sometimes such removal is not desirable. Again, a simple experimental procedure is available as follows. First, either the coasting time (t_1) or the coasting angle (α_1) of the output shaft from a certain initial speed is measured. Then a cylindrical flywheel of known moment of inertia (I_f) is mounted on the shaft and observation made of the new coasting time (t_2) or coasting angle (α_2) from the same initial speed.

Since the deceleration of a rotating body is inversely proportional to its moment of inertia it follows that both the coasting angle and the coasting time is directly proportional to the moment of inertia. Therefore the following relation is valid:

$$\frac{t_2}{t_1} = \frac{I_r + I_f}{I_r}$$

From which, the following expression is obtained for rotor moment of inertia.

$$I_r = \frac{t_1 \times I_f}{t_2 - t_1}$$

When coasting angles are used, the expression reads:

$$I_r = \frac{\alpha_1 \times I_f}{\alpha_2 - \alpha_1}$$

The above method assumes that the flywheel does not cause any appreciable additional windage or friction torque.

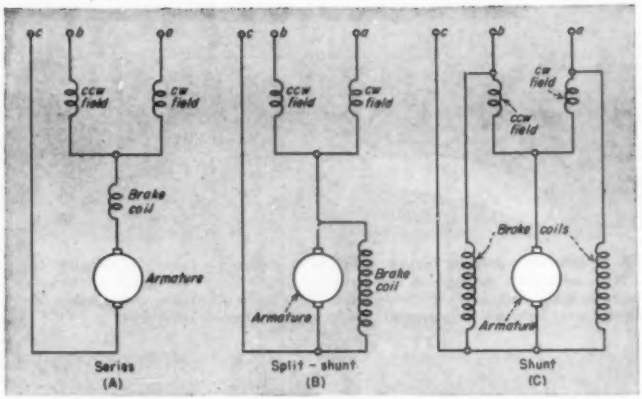


Fig. 3—Brake performance is affected by arrangement chosen to connect brake coil into the servo circuit. The three possible circuit arrangements are shown above. The series circuit is most often used for its fast action, low power drain.

Brake Coil Connections

It is obvious from the above that coasting angle can be minimized by keeping rotor inertia as low as possible and by proper choice of brake linings. In addition, designers must carefully select the type of circuit used for the brake coil, since this also affects the stopping characteristic of the servo. The brake coil of a split series motor is usually connected in series, in shunt or in split shunt, as shown in Fig. 3.

The series brake has several advantages. The brake coil current is interrupted simultaneously with the line current. Therefore, tripping time (t_t) is short—on the order of 0.005 seconds. This delay is caused by eddy currents in the magnet core, and increases with the size of the brake. The decay of the eddy currents can be accelerated by using silicon steel for the brake core. The specific resistance of silicon steel is about three times higher than that of ordinary low carbon steel. This higher resistance steel speeds decay of the eddy currents. Another method with similar effect is the milling of radial slots into the brake core, thus lengthening the path of the eddy currents.

With a series connection, the brake plate is pulled in quickly even when starting the motor at about half of its rated voltage. This is because of the high inrush current. Power consumed by the brake coil at rated motor speed is small. The force needed to pull in the brake plate is supplied by the inrush current. When the servo motor comes up to speed, line current decreases considerably but is sufficient to hold the brake plate securely.

The series connected brake coil has disadvantages too. First, the stalled torque of the motor is reduced somewhat by the resistance of the brake coil. Second, line current is of sufficient magnitude to pull in the brake plate only when the motor is at standstill or turning at low speed. Should line voltage be interrupted momentarily with the motor running at full speed, the brake may trip. Then, if voltage is reestablished before motor speed has dropped sufficiently, line current will not be great enough to pull the brake plate. The motor will drive against the brake until damage occurs or the current is cut off by some protective device. It should be noted that this kind of failure is not common to all series brake motors. It will happen only if the current of the motor when running against the brake, is insufficient to pull in the brake plate.

A shunt connected brake coil, on the other hand, acts independently of motor speed. Coil current is sufficient to pull in the brake plate at any motor speed. But in a shunt brake,

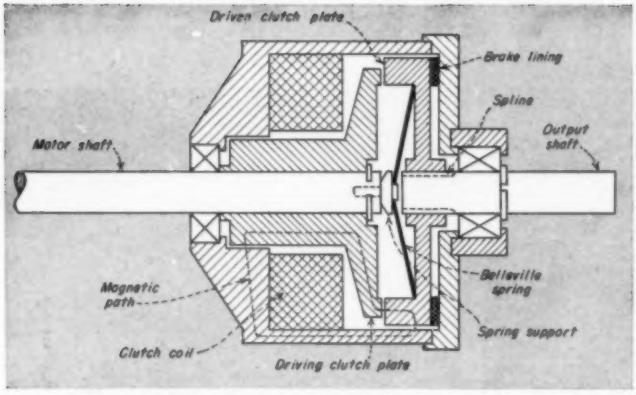


Fig. 4—Clutch-brake combination is recommended for the larger servo motors, which have comparatively high rotor inertia. At signal cut-off, clutch frees rotor from output shaft. Brake does not, therefore, have to stop the spinning rotor, only the shaft.

tripping time is appreciable because coil current decays slowly. The potential established by the decaying flux works on a complete circuit, consisting of the brake coil and the motor armature. The rate of decay of the brake coil current depends on the inductance and resistance of this closed circuit. The tripping time can be reduced substantially by providing an airgap of about 0.01 in. in the magnetic path of the brake. With a careful design, the tripping time can be held to about 0.05 second. The power consumed by the shunt brake coil is considerably higher than that of a series brake coil. With the motor at standstill the power input to the brake coil is at minimum because it is limited by the voltage drop in the series field coil. With the motor running at no load this voltage drop is negligible and the power input is at its maximum.

The characteristics of the split shunt brake are basically the same as those of the shunt brake, except that the difference of input power between standstill and no load speed is not as pronounced. Therefore, the power consumption is somewhat less.

The shunt brake coil is rarely used for a servo brake because of its long tripping time. However, it is necessary to use a shunt coil in a clutch-brake combination, as will be explained. The series brake is most popular. The tripping time of a series brake usually can be neglected, making the coasting angle proportional to the square of the initial speed of the motor. With small motors (up to about ¾ hp), it is quite feasible to obtain a coasting angle of 10 revolutions from an initial speed of 10,000 rpm.

In order to obtain fast stopping, a high ratio of brake torque to armature inertia is necessary. The larger the motor size, the more difficult it becomes to obtain this high ratio of torque to inertia. To demonstrate this point, assume that all linear dimensions of a given motor are increased "n" times. Examination of formula (3) shows that the moment of inertia of the armature will increase as the fifth power of "n". (W is proportional to n^5; D is proportional to n). But, assuming constant unit pressure on the lining, braking torque increases only as the third power of n (lining area is proportional to n^2; effective braking radius is proportional to n). Thus, the ratio of brake torque to rotor inertia is inversely proportional to the square of the linear dimensions. The coasting angle is in turn adversely affected as motor size goes up.

This difficulty can be overcome by using a disconnect clutch-brake, such as that shown in Fig. 4, in the larger servos. When the clutch coil is energized, the driven clutch plate is pulled magnetically against the driving clutch plate. The output shaft is thereby coupled to the motor shaft. With the clutch coil deenergized, the driven clutch plate is pushed against the brake lining by the Belleville spring, simultaneously disconnecting the output shaft from the motor shaft. Thus, the output shaft comes to a rapid stop, while the armature coasts until its kinetic energy is consumed by bearing, brush and windage friction.

The clutch coil must be connected in shunt. A series coil would not pull in the driven clutch plate, if the unit were energized with the armature coasting at high speed. This design stops the output shaft effectively once the driven clutch plate has tripped. Special care has to be taken to obtain a short tripping time.

Often in aircraft applications, an actuator is desired whose output torque does not rise beyond a certain limit. This requirement may be intended as a safety measure, in the event of nonoperation of a limit switch. This can be effected by use of clutch-brake. In such cases, the clutch has two functions, that of a disconnect and that of an override clutch. To make the design of Fig. 4 function as an override clutch, some means of adjusting the slip torque must be provided and the clutch must be capable of absorbing a maximum of energy.

The slip torque can be regulated by adjusting the force of the spring opposing the magnetic pull. The higher the spring force, the lower will be the slip torque. One way of adjusting the spring force is to insert shims behind the spring support. The sketch of Fig. 5 shows a method of adjusting the spring force by turning a nut accessible on the assembled unit. To be suitable for maximum energy absorption, the clutch linings should be metal to metal, or metal to sintered metal. These materials yield the best results because of their high thermal conductivity and stability. Bonded asbestos affords smooth slipping performance but is apt to carbonize.

In contrast to the open loop system, closed loop servomechanisms do not incorporate brakes. This is a feature that contributes to the popularity of closed loop systems, which are used wherever the accuracy required justifies their cost. In a closed loop system, the strength of the signal is related to the magnitude of "error"—i.e., the difference in position between the pickup shaft and the shaft of the output servo. The servo rotor does not need a brake, because the motor approaches the commanded position with decreasing speed corresponding to the decreasing error signal. If the system is properly designed, the output rotor follows the pickup shaft without appreciable lagging or overshooting.

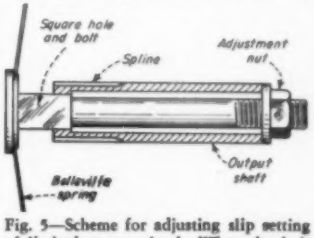
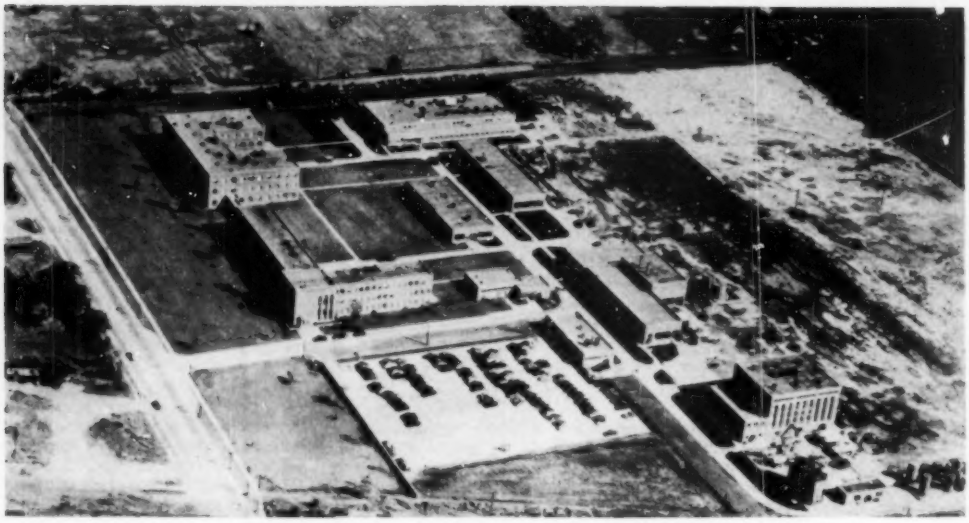


Fig. 5—Scheme for adjusting slip setting of limited torque clutch. When the bolt holding the Belleville spring is moved to the left, clutch slips at lower torque.

TECHNICAL NEWS



Inventors Can Use This Research Plant - - - Gratis

FACILITIES OF THE HUGE SINCLAIR RESEARCH LABORATORIES at Harvey, Illinois, are now available to any American with an idea for a new or better petroleum product or application. This, in brief, is the scheme incorporated in the "Sinclair Plan" announced recently by P. C. Spencer, President of the Sinclair Oil Corporation.

This latest idea in cooperative research stems from the fact that few simple things remain to be invented. Years ago an amateur mechanic or scientist could invent and prove a device in his basement or garage, and with his own money. Henry Ford, Edison, the Wright brothers are some of the hundreds of self-sufficient inventors of the past.

Today, however, most developments and inventions are complex. The man with an idea often needs years of time, the help of many specialists and a great sum of money. Few inventors have sufficient resources to develop an idea fully on their own.

The "Sinclair Plan" is aimed at restoring initiative to individual inventors. The plan provides all the necessary technical facilities and skilled personnel to any American with an accepted idea, to bring that idea from the roughest scratch-pad stage through to final pilot plant testing.

At the Sinclair Research Laboratories are extensive facilities for the research, development and pilot-plant testing of all ideas relating to petroleum and petroleum products. A portion of the complex plant will be made available to the public under the new plan. The Laboratories will test the most promising ideas selected by the Laboratories' Directors. In return for its investment of money, time, facilities and personnel, Sinclair receives the privilege of using the invention free of royalties.

The plan in no way impairs the inventor's opportunity to sell his idea in all other quarters, or to make any kind of arrangement he wishes outside of his agreement with Sinclair. Every idea submitted must first be protected by a patent application or a patent.

The Laboratories are located on a 38 acre site in the suburbs of Chicago. They consist of 9 new and modern buildings, most of them air-conditioned and soundproofed, with a total floor area of 200,000 square feet. Working in these laboratories are many hundreds of chemists, physicists, engineers, technicians and representatives of more than a score of different professional callings.

Installations include analytical and physical chemistry labs, distillation rooms, X-ray labs, combustion test departments, wax-processing rooms, engine laboratories, test fleets of automotive vehicles and pilot-plant buildings.

New Electronic Brain Ready for its Exam

WITH THE COMPLETION OF the pilot model of the National Physical Laboratory's automatic computing engine, known as Ace—Automatic Computing Engine, to distinguish it from other ingenious members of the family in Britain and America, which already includes the Eniac, the Edvac, Seac, Swac, and even (in Massachusetts) the Maniac—the Department of Scientific and Industrial Research will be glad to hear of problems which require long and intricate arithmetical calculations. The Ace itself will be built later, but the model, which was demonstrated to the press at the National Physical Laboratory, Teddington, last November, is non the less a complete electronic calculating machine, claimed as one of the fastest and most powerful computing devices in the world.

The automatic computing engine

uses pulses of electricity, generated at a rate of a million a second, to solve all calculations which resolve themselves into addition, subtraction, multiplication, and division; so that for practical purposes there is no limit to what Ace can do.

Possible applications range from synthesis of penicillin and cortisone to the designing of guided missiles for anti-aircraft defense.

On the machine the pulses are used to indicate the figure 1, while gaps represent the figure 0. All calculations are done with only these two digits in what is known as the binary scale. When a sum is put into the machine, the numbers are first translated into the binary scale and coded; instructions are also given to the machine by coding them as holes in cards. To carry out long sequences of operations the engine must be endowed with a memory.

The memory section is highly complicated. It depends upon the slower time of travel of supersonic waves, into which the electric pulses are converted, through a column of mercury. One thousand pulses—representing digits—can be stored in this way and extracted when they are needed by the arithmetic section, which handling pulses of electricity, works 100,000 times faster than the supersonic section. The completed calculation appears in code as a holed card, representing the answer in the binary scale, which is translated back into ordinary numbers.

After about six months experience with the pilot model, work will begin on the Ace proper, incorporating any modifications suggested by these tests.

New Recorders Provide Test Data Immediately

TWO NEW INSTRUMENTS have been developed to speed up the processing of test data. The first was developed by Boeing Aircraft to meet the need for immediate knowledge of five critical aerodynamic functions of an airplane in flight tests. It is a graphic flight recorder which replaces the former method of recording the information on film and waiting two weeks for transcribing of the details. Film records are still taken of 14 less critical aerodynamic functions as well as engine data.

Aptly named "Wigglin' Willy," the machine has six pens. One pen marks off time intervals while the others record air speed, angle of pitch, normal acceleration, elevator position and elevator hinge moment. With minor changes, altitude, pressure, temperature and other functions can be substituted for these functions.

The machine writes on a moving roll of graph paper 150 ft. long. It has four speeds, ranging from 1½ to 75 in. a minute, depending on the degree of fineness to which the values of the various functions must be ascertained.

Arm of each pen has a "pickup" for sensing the varying degree of the function. Air speed is sensed by a Kollsman Synchrotel; angle of pitch by an L-1 vertical-control gyro with an autosyn fastened to its gimbal shaft; normal acceleration by a seismic weight suspended on unbonded strain gauges; elevator position by an autosyn position transmitter connected to the elevator; and elevator hinge moment by strain gauge bonded to the piston rod of the boost package.

These arms are so responsive they can record the weight of the pilot's finger on the control wheel or measure the weight of the airplane. When motion occurs at the point of function, the sensing unit transmits an electrical impulse in exact proportion to the value of that motion. This impulse, amplified actuates a motor which guides the pen in a straight line over the moving sheet of graph paper, at right angles to the direction in which the paper moves. Ink is supplied to the pen from a well through a small flexible rubber hose.

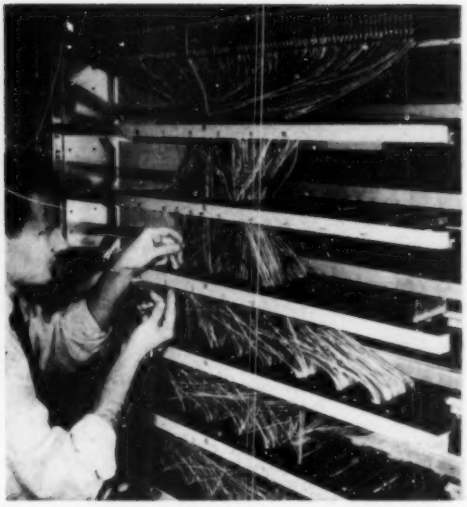
Each pen is carried on a "trolley" whose wheels are fitted with jewel bearings. This trolley is pulled back and forth along a straight-line truck by a nylon thread attached to the rotor of a servo motor. The trolley assembly—all the pen's moving parts—weighs only 1.9182 grams, as compared to 3.0822 grams for a copper penny.

The other is a new electronic device which reads test instruments at speeds up to 50,000 readings per second and records, the readings on tape or punched cards ready for computation.

Developed by Arthur D., Little, Inc., the "Digital Reader", is expected to eliminate cumbersome human work involved in recording and computing from strain, pressure, acceleration and temperature gauges, pilot plant and other physical and control instruments used in research work in a number of industrial fields. When linked to the instruments to be recorded, it rapidly converts electrical signals received from the instruments directly to convenient binary-digital form for immediate analysis, computation, smoothing or storage on recording media. The unit is about 20 x 30 x 5 in., operating from 110-125 volts, and easily incorporated in a variety of multiple-instruments reading and recording systems.

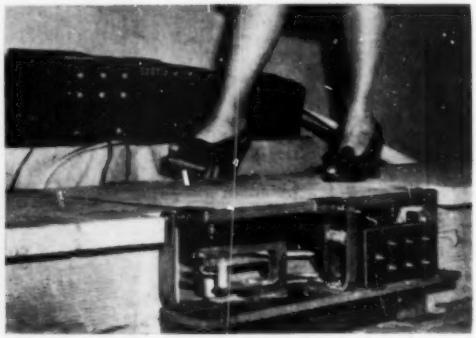
"WIGGLIN WILLY" records five critical aerodynamic functions of a plane during flight tests. The counter on the left of the machine records time in seconds on the moving roll of graph paper.

ATOMIC WATCHDOG. Pocket-size radiac, a precision instrument developed by the Navy for detecting atomic radiation, weighs only two pounds and is powered by flashlight batteries. Two subminiature tubes make possible this simplicity and portability. One, a gas-type Geiger counter tube, operates the radiac without the need for electronic devices. The other, a corona voltage regulator tube, provides a stable source of high voltage for the Geiger tube. In the lower range of the scale, the radiation intensity is indicated audibly as well as visually. Exposure for an hour at 500 roentgens per hours, the upper scale limit, would be fatal. Although this instrument is intended for military uses, AEC is developing a similar one for non-military applications. Official Navy Photo Released by Department of Defense.



CROSS-COUNTRY CROSSROADS. This electronic translator being assembled by a Bell Telephone Laboratories' engineer is part of the intricate dial equipment which makes possible cross-country dialing by subscribers. Cross-country dialing will be inaugurated this fall when telephone users in Englewood, N. J. will be able to dial subscribers in selected cities as far distant as San Francisco. The intricate switching apparatus, development of which climaxes years of research, will enable subscribers to span the continent through 10 pulls of the dial instead of the customary seven now used in completing calls to shorter distances. In the initial phase of cross-country dialing, 10,000 customers in the Englewood exchange area will be able to dial directly to any of 11,000,000 telephones in such cities as San Francisco, Chicago, Cleveland, Detroit, and Boston.

SCIENTIFIC CAVALCADE. Led by a 1915 model, four Cadillac automobiles are submitted to test runs on Arizona roads. Purpose of the tests is to obtain performance data for use in evaluation of the General Motors "19xx" experimental engine. Last car in the procession is equipped with the new V-8 engine, which has a 12 to one compression ration. Other cars in the line are powered by 1951 and 1935 stock engines. Each car is fueled with specially compounded gasolines, exactly duplicating the fuels available commercially in its era. The "19xx" engine uses a high octane fuel that automotive and petroleum men believe will be feasible in years to come. The survey showed that from 1915 to 1951, fuel economy in terms of miles per gallon increased more than 100 percent.

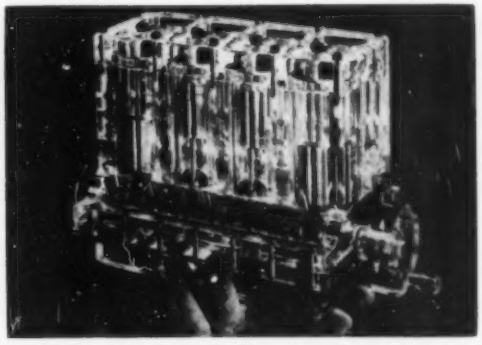


WATCHING HER STEP. Electronic stepmeter developed at the National Bureau of Standards measures the vertical and horizontal components of the forces exerted on a surface by the leg during walking. The object of this research project is the elimination of the hazards imposed by slippery walkways. The platform of the device is mounted on ball bearings attached to four J-shaped springs. The four sides of the platform bear against ball bearings attached to L-shaped springs which are kept under slight tension so that all will follow the horizontal motion of the platform. Electromechanical pickups are mounted adjacent to the appropriate springs. Deflections of the springs due to forces exerted against them produce output voltages in the pickups proportional to the forces in each of three directions.

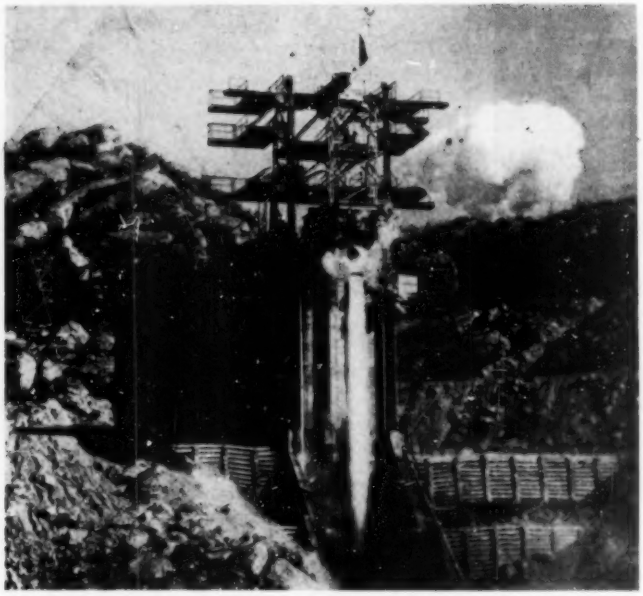
FLYING BLUEPRINTS. One large West Coast manufacturer uses a 1-1/3 mile pneumatic tube system to speed blueprints from the central blueprint station to outlying technical departments—engineering, experimental, machine shop, production, assembly, inspection or maintenance. The system minimizes interdepartmental manual handling of prints. Savings in blueprint production costs are also claimed. Previously, as many as 15 copies of a given print would be required whereas now only two are needed—one "on call" the other "on reserve". Designed by the Lamson Corporation, Syracuse, N. Y., the system comprises a 3x12 in. pneumatic tube network reaching from the central blueprint station to six substations. When someone wants a print, he calls the central station. The desired print is placed in a container (see above), sent by tube to the nearest substation.

THIS LAB GETS AROUND. Use of mobile laboratories by the U. S. Army is increasing. The latest addition is a Mobile Materials Laboratory now under test at the Engineer Research and Development Laboratories, Fort Belvoir, Va. The laboratory contains the equipment necessary to run tests on materials going into road and airfield construction. It can be set up for operation anywhere in the world. Shown above is an interior view of the laboratory, which is housed in a 28 ft air-conditioned van. Equipment will include devices for running Bearing Ratio tests on soil, stability tests for asphalt design and flexual strength tests on concrete. Also included will be a generous sized drying oven, a compaction pedestal built into the floor of the van and supported from the ground by a separate jack as well as a hot water bath and sink with running water.

AND MORE TO COME. This is the billionth pound of American rubber produced in 8 years at the government's Port Neches, Texas synthetic rubber plant operated by B. F. Goodrich Chemical Company. This fact was announced recently by William S. Richardson, company president. The Port Neches plant, with rated capacity of 60,000 long tons per year, produced its first pound August 18, 1943. It continued in production after the war when most other government rubber plants were put on a standby basis. At the present time, of course, the continued operation of this plant has proven to be a very advantageous situation as far as National Defense is concerned. It is expected that there will be considerable delays before the many plants that were deactivated can get back into full production.



TRANSPARENT HANDFUL. Unusual craftsmanship in plastics is represented in the visual study model of a four-cylinder gasoline engine, recently made of acrylic plastic by Philip A. Derham and Associates, design engineers of Rosemont, Pa. The assembly, designed and fabricated to illustrate the close tolerances which could be held and the perfect visibility of working parts attainable in industrial models with this transparent material, measures about eight inches long, six inches deep and four and one-half in. wide. Block, cylinder head, crankcase, flywheel and motor mounts were machined from solid clear Plexiglas. Rugged acrylic brackets support the miniature engine when it is on display. The pulley permits manual operation, or slow-speed drive from a small electric motor.



Mountain Test Stand for Rockets

ROCKET POWER developed by this guided missile engine is being measured on static test stand at North American Aviation's Aerophysics Field Laboratory high in the Santa Susana Mountains north of Los Angeles. Rocket motors which will power guided missiles under development by NAA develop thousands of pounds of thrust it is claimed.

Bath Tub for Prospectors

LOS ANGELES—Improved methods of "scientific prospecting" may result from a new electromagnetic model laboratory just completed by the Institute of Geophysics on the Los Angeles campus of the University of California.

Under the direction of Dr. Louis B. Slichter, director of the institute, research is aimed at increasing the efficiency by which ore bodies below the surface of the ground can be located.

Support for this important work has come from such interested agencies as the N. J. Zinc Company, the United Geophysical Company of Pasadena, and the United States Steel Corp., as well as from a fellowship furnished by the Shell Petroleum Company.

The new piece of equipment, only one of its type in the world, resembles an immense bath tub or small swimming pool, 12 feet long, 7 feet wide, and 4 feet deep. Running lengthwise over the top of this concrete tank is a wooden track which supports (1) the measuring devices, (2) the electrical equipment and (3) the ore body to be studied.

Actually, the tank is an electromagnetic model of the earth, although its appearance is far from the familiar round shape. Nearly any condition, so far as relative electrical conductivity of ore and earth is concerned, can be simulated inside the tank. A model laboratory for studying electrical prospecting problems fills the same kind of need as do other types of model laboratories, such as wind tunnels in aeronautics and towing basins in ship design.

In electromagnetic prospecting, an electrical generator creates an oscillating magnetic field, which fills the surrounding space.

When an electrically conducting ore body gets in the way of the oscillating field, the ore distorts the "flow lines" of the field, just as a large rock on the bottom of a stream deflects the current and causes a permanent ripple or wake at the surface. The scientific prospector looks for the "electrical ripple" and so finds the conducting ore below which produces the ripple. Each ore body sends up a recognizable kind of ripple.

Canning Season for Jet Engines

LARGE STEEL CONTAINERS, in which huge jet aircraft engines are "canned," shock-mounted and sealed against humidity, are being delivered to the U. S. Air Force by Rheem Manufacturing Company. The special containers protect jet engines both from damaging vibrations in transit and from moisture during storage over indefinite periods in the open. During an amphibious operation, engines in these containers can be lowered overboard and floated ashore without damage.

The first steel engine containers, designed for piston engines, were basically over-size versions of the familiar oil drum, sealed mid-way between the ends of the drum and provided with shock mounts and humidity control and indicators. Development of a similar container for jet engines posed numerous problems, because such power plants are mounted differently than radial engines and are more sensitive to vibration in transit. The new jet container is cylindrical in shape but is designed to be placed horizontally rather than vertically. It opens along a longitudinal seam into two halves shaped somewhat like bath tubs. The container is mounted on skids so it can be towed along difficult terrain and still keep the engine in the proper position.

Engines of both types are placed in containers on completion of testing at the assembly plant. Each container is hermetically sealed and filled with dehumidified or dried air under light pressure. Relief valves release pressure if it builds up too high, and an external humidity indicator shows if moisture enters the container.

School for Balancers

THE GISHOLT MACHINE COMPANY has begun a series of intensive courses on the subject of unbalance in rotating parts. The school is conducted in the Gisholt plant in Madison, Wisconsin and consists of both lectures and laboratory work.

The Gisholt people decided to set up the school because of the lack of widespread knowledge on the subject. The

balancing machine is a relatively new production tool. Tool engineers, production men and maintenance men cannot use these tools at their utmost effectiveness without becoming familiar with the theoretical and practical aspects of the balancing of rotating parts. The product design engineer comes into the picture, too, since he needs instruction to design parts that will lend themselves to most accurate and economical balancing.

There are two courses offered—one of two weeks duration and a second lasting three weeks. The courses cover unbalance in rotating parts; causes and effects of unbalance; methods of applying correction for balance in rotating parts; and thorough study in the operation and maintenance of balancing machines. Write the Gisholt Machine Company, Madison 10, Wisconsin for information on tuition and student qualifications.

New Motor Selection Course for Industry

A NEW EDUCATIONAL PROGRAM designed to help train personnel in the proper selection and application of modern electric motor drives has been announced by the General Electric Company. Specifically, it shows how motors operate, what types are available, the characteristics of each type, and how to select and apply the right motor for a particular job.

This Motor Selection and Application Course consists of nine 35 mm black-and-white slide films, student review booklets on each lesson, and a 96 page instructor's manual. Each film has a running time of 15 to 30 min and is accompanied by a sound recording of the script. The first three films present the basic principles of motor operation and selection. The remaining films are on a more advanced level and deal with the operating characteristics of the various types of motors and the part these characteristics play in proper motor selection.

The course is available at G. E. district offices throughout the country for showings to interested groups. These will include users and potential users of electric motors, application engineers, power sales engineers, machinery manufacturers, designers, contractors, consulting engineers and students. The entire kit, consisting of the nine films, one instructor's manual, and ten copies each of the nine student booklets may be purchased for $100.

THE EARLY REQUESTS FOR exhibit space at the National Metal Congress and Exposition in Detroit during the week of October 15-19 indicates a record number of industrial firms will be represented. Sparked by the Saturday and Sunday (Oct. 13-14) Seminar, nearly 250 technical papers will be presented by the world's authorities in metallurgical science. The Seminar itself will cover Interfaces or the study of boundaries between crystals in any metal.

•

NINETY-NINE NEW AND REVISED American Standards are listed for the first time in the latest edition of the Price List of American Standards just published by the American Standards Association, 70 East 45th Street, New York, N. Y. This list contains more than 1,180 standard specifications, methods of test, and symbols and abbreviations in civil engineering and construction, mechanical engineering, electrical engineering, safety codes, ferrous and nonferrous materials and metallurgy, rubber, textiles, mining, pulp and paper, photography, motion pictures, and gas burning appliances.

•

AUTOMATIC CORRECTION-COMPUTING CHRONOGRAPH developed at the National Bureau of Standards makes possible large savings in the time required to test docks, watches, chronometers, and other timepieces. A differential gear system is used to subtract indicated time from standard time and the operator merely records this correction which is shown on the dials of a revolution counter. Human error is reduced to a minimum.

•

OFFICE OF TECHNICAL SERVICES has started a technical digest service to scan the trade press and compile synopses of significant items. These one page digests are sent to the productivity centers in 18 European countries to be translated and distributed.

•

A 15,000-KW GAS TURBINE-GENERATOR, the largest yet ordered for commercial generation of electric power, will be installed in the Bartlesville area of the Public Service Company of Oklahoma by the Westinghouse Steam Division. The 700,000-lb turbo-generator installation will consist of the gas turbine, driving a hydrogen-cooled generator. The gas turbine will comprise high and low pressure turbines driving high and low pressure compressors, respectively, with the high-pressure turbine also connected to drive the generator. Intercoolers will reduce the temperature of the compressed air between stages of compression, and a regenerator will apply exhaust-gas heat to the air before it enters the combustor to reduce fuel consumption. The turbines will operate at a temperature of 1350 degrees F—300 degrees higher than the hottest steam temperatures in use today in electric generating stations and about twice as high as the temperature of the average steam generating plant. Speed of the turbine will be 3600 rpm. At full load the compressors will draw in seven and a half tons of air every minute. Natural gas will be used as fuel.

•

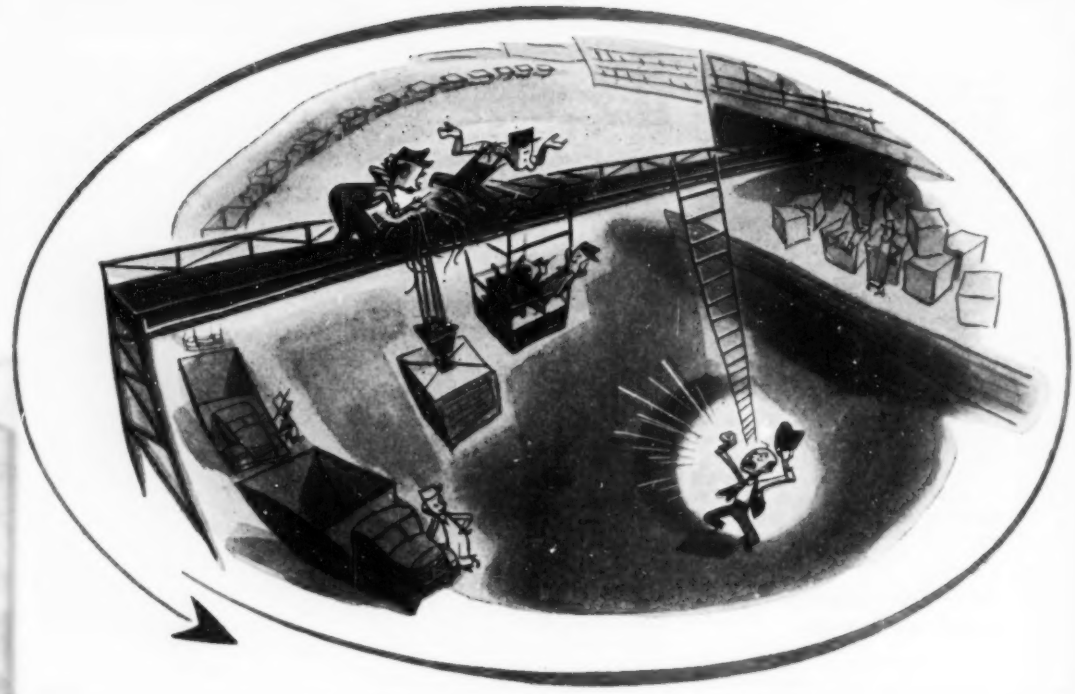
A REVOLUTIONARY METHOD OF METAL PLATING developed by Westinghouse Electric Corporation engineers in 1948 may conserve critical nickel and still provide the nation's new automobiles and appliances with bright, corrosion-resistant trim. The new process provides a chrome-on-copper finish that is as bright as the standard finish and has satisfactory corrosion resistance. Where some nickel is permitted, it is possible to substitute copper for a major part of the nickel normally used.

•

MANUFACTURING FACILITIES of dry colorants for the coloring of crystal styrene and other thermoplastics has been added by Mid-America Plastics, Inc. of Cleveland, Ohio. Called Colorblende, it is available in seventeen colors matching the Bureau of Standard's colors. Variations and modifications of these colors are possible and are available on request. The process requires only simple mixing of Colorblende with the crystal styrene by dry tumbling. A dispersing agent is suggested to obtain uniform coloring.

•

Although the Colorblende adheres to the crystal styrene in preference to the walls of the drum container, it is advisable to use a dispersing agent to assure uniform coloring of each crystal of styrene. Once the dry coloring operation is set up it requires only 15 to 30 minutes of blending. Crystal styrene dry colored with Colorblende can be molded satisfactorily in molds having pin point or restricted gating. The nozzle on the molding machine should be a mixer type with an opening of not over $\frac{1}{8}$ inch.



Burned-out Motors Waste Manpower!

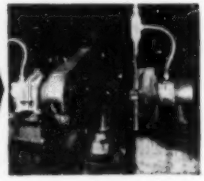
Men without motors are just about as helpless in a modern factory as a wagon without wheels on a superhighway.

In many plants the failure of a single motor used to drive an overhead crane or a conveyor system can cost thousands of dollars an hour in lost production and wasted man-hours of labor.

The answer is Class H insulation made with Dow Corning Silicones. In a steel mill, for example, a cupola crane hoist motor insulated with the best Class B materials had an average life of only 50 days. Rewind costs alone amounted to $3,634 in three years. That motor, rewound with Class H insulation at an extra cost of only $79 was still in good condition after 613 days on the hoist and 908 days on the trolley bridge.

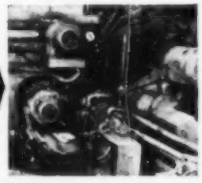
And Class H is readily available. Most of the best rewind shops now feature this longer lasting, more reliable class of insulation. Leading motor manufacturers are quoting price and delivery on new Class H machines.

In Critical Motors which determine your productive capacity . . .



In Overloaded Motors whether the load is intermittent or sustained to meet increased production schedules . . .

In Motors Exposed to High Ambient Temperatures or Excessive Moisture—Specify Dow Corning Silicone Insulation.



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Buckling Strength of Rectangular Sandwich Panels

N. J. HOFF
Polytechnic Institute of Brooklyn

IN AIRCRAFT CONSTRUCTION, extensive use has been made of sandwich panels which consist of two thin outside faces of metal (usually aluminum alloy) and a thick core made of some light-weight material (expanded plastic or balsa wood). In this type of structure the core material is unimportant in resisting the bending moments since its modulus of elasticity is extremely low in comparison to that of the face material. However, the core is important in transmitting shear forces and as a result considerable shearing deformations of the core occur.

To calculate the buckling load for a simply supported plate which is subjected to edgewise compression, a series of charts have been prepared. These charts simplify the necessary computations and are based on an investigation reported in NACA TN 2225.

Referring to Fig 1, the maximum or critical load (P) that a one inch width of a sandwich panel can withstand without buckling is given by the equation:

$$P = 2\,t\,s_c \tag{1}$$

where t is the face thickness and s_c the critical stress in the panel. This critical stress,

$$s_c = F\,\sigma\,C \tag{2}$$

where the Form Factor,

$$F = 1 + 3\left[1 + \frac{c}{t}\right]^2 \tag{3}$$

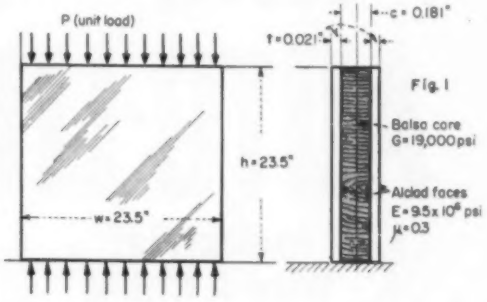
and the buckling stress of the two faces (when not connected) is,

$$\sigma = \frac{\pi^2\,E\,t^2}{3\,(1-\mu^2)\,w^2} \tag{4}$$

in which, E is Young's modulus (psi); μ is Poisson's ratio, and W is the panel width. The Load Reduction Factor C is a function of the parameter R and can be obtained from Fig. 2. This bucking parameter,

$$R = \frac{G}{F\,\sigma} \tag{5}$$

where G is the shear modulus of the core material.



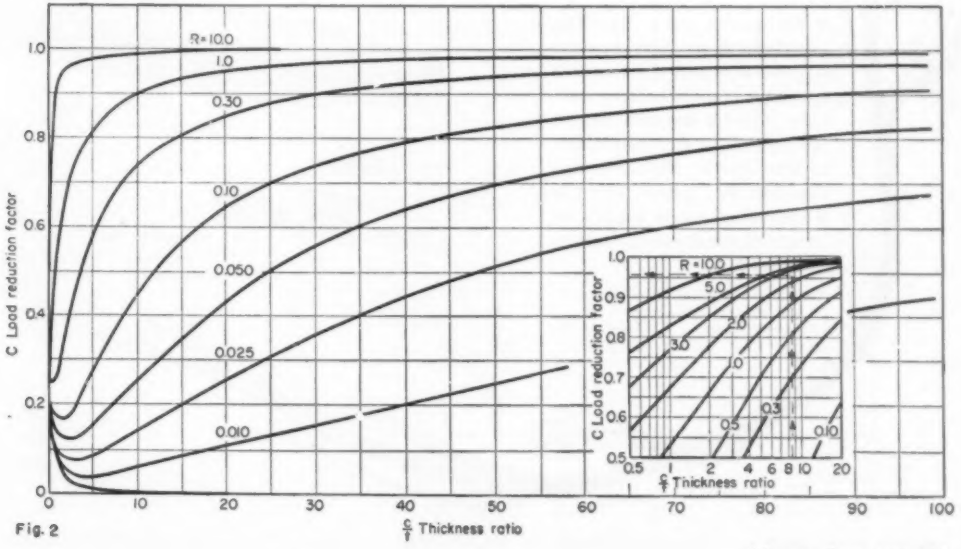


Fig. 2

(*Continued on page* 185)

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Buckling Strength of Rectangular Sandwich Panels (continued)

EXAMPLE:

Calculate the buckling strength of a square panel with the proportions and data shown in Fig. 1.

From Eq (3), the Form Factor

$$F = 1 + 3\left[1 + \frac{0.181}{0.021}\right]^2 = 278$$

From Eq (4), the bucking stress of face material,

$$\sigma = \frac{\pi^2 \times 9.5 \times 10^6 \times (0.021)^2}{3 \times 0.91 \times (23.5)^2} = 27.25 \text{ psi}$$

and from Eq (5), the buckling parameter,

$$R = \frac{19000}{278 \times 27.25} = 2.51$$

With this value and $c/t = 8.62$, the Load Reduction Factor C can be obtained from Fig. 2 (See inset):

$$C = 0.955$$

Using Eq (2) the critical stress is determined:

$$\sigma_c = 278 \times 27.25 \times 0.955 = 7220 \text{ psi}$$

Finally, the critical load per inch of width of panel is (from Eq 1):

$$P = 2 \times 0.021 \times 7220 = 303 \text{ lb per in.}$$

The total load carried by this panel is:

$$P_t = 303 \times 23.5 = 7120 \text{ lb.}$$

This calculated value is in satisfactory agreement with four specimens that were tested and failed under loads ranging from 266 to 300 lb per in.

It will be noted that in Fig. 2 the Load Reduction Factor does not depend on the width w or on the Panel size ratio h/w. This is not rigorously true but is correct in very good approximation for those types of panels commonly used.

Fig. 3 graphically illustrates the effect of the panel thickness and size on the buckling load which is expressed as a Stress Ratio λ. This ratio is equal to the critical buckling stress of the panel divided by the buckling stress of the panel faces if not attached together. It can be also expressed as a ratio of the corresponding loads. The family of curves in (A) illustrate the increased buckling strength of panels with thicker cores. In addition, the Panel size ratio h/w is shown to have no effect on the buckling load in the region to the right of the vertical dotted line. Chart (B) is used for determining the Stress Ratio for values of c/t other than those plotted in (A).

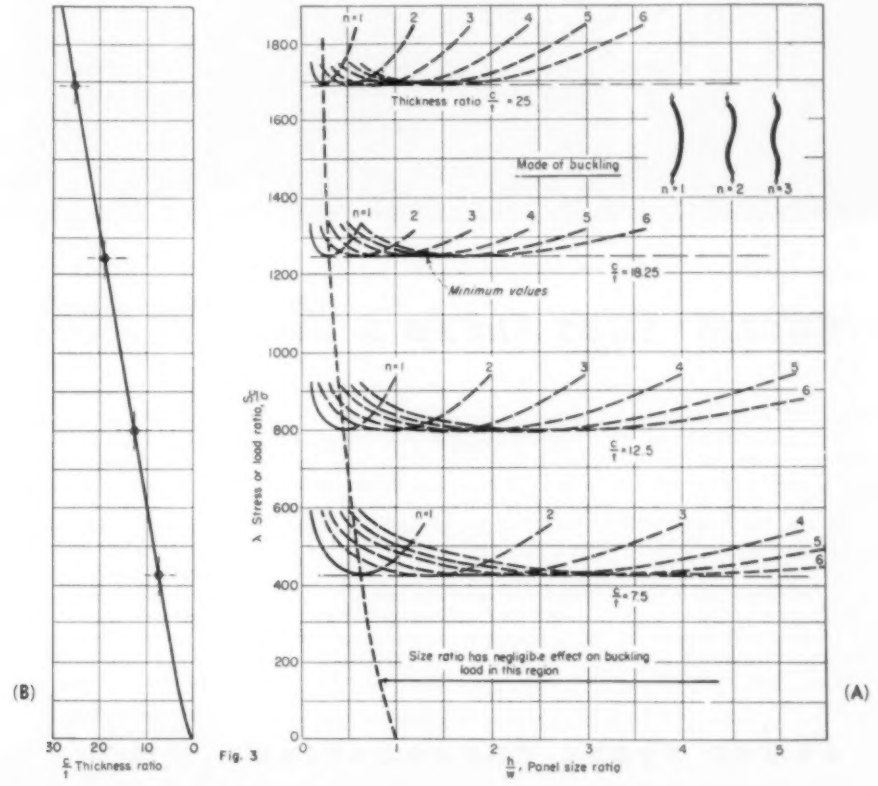


Fig. 3

THE "DREAM" THAT SAVED A *BILLION DOLLARS!*

Steel users saved a *billion dollars last year* . . . all because an Armco "dream" came true just 27 years ago.

It was the continuous mill for rolling steel sheets. Before 1924, all steel sheets were rolled on hand mills. It was slow, back-breaking labor, and was costly. But the vision and persistence of Armco engineers changed all that.

They designed the revolutionary machine that has been called one of the world's great inventions. It reduced thick slabs of steel to thin sheets in stand after stand of giant rolls!

Armco licensed this new invention to other steel companies to make the benefits of more and better steels available to fabricators and the public. Many continuous mills were built. Production of sheet steel moved steadily upward. More products for better living came into being.

Last year American mills turned out the staggering total of *25 million tons* of steel sheets and strip. Had this tonnage been rolled on hand mills, it is conservatively estimated the steel would have cost manufacturers an *additional billion dollars.*

The continuous mill is one big reason why you can still buy plain steel for a *nickel a pound.*

But cost-savings are not the only advantage of the Armco-invented continuous mill. It also makes possible more uniform steels—sheets with a better surface that help you build greater usefulness and longer life into the products you make.

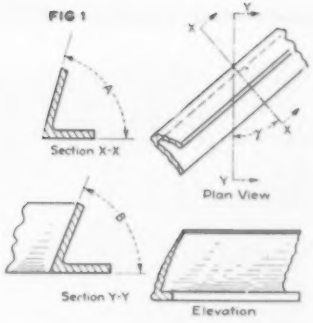
ARMCO STEEL CORPORATION

3171 CURTIS STREET, MIDDLETOWN, OHIO • PLANTS AND SALES OFFICES FROM COAST TO COAST • EXPORT: THE ARMCO INTERNATIONAL CORPORATION

ARMCO

Chart for the Resolution of Angles

FIG 1



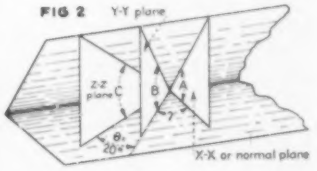
As shown in Fig. 1, the resultant angle B from the intersecting plane (Y-Y) of an angularly shaped part can be determined by layout methods. However, this chart can be useful to designers by reducing the necessary work required.

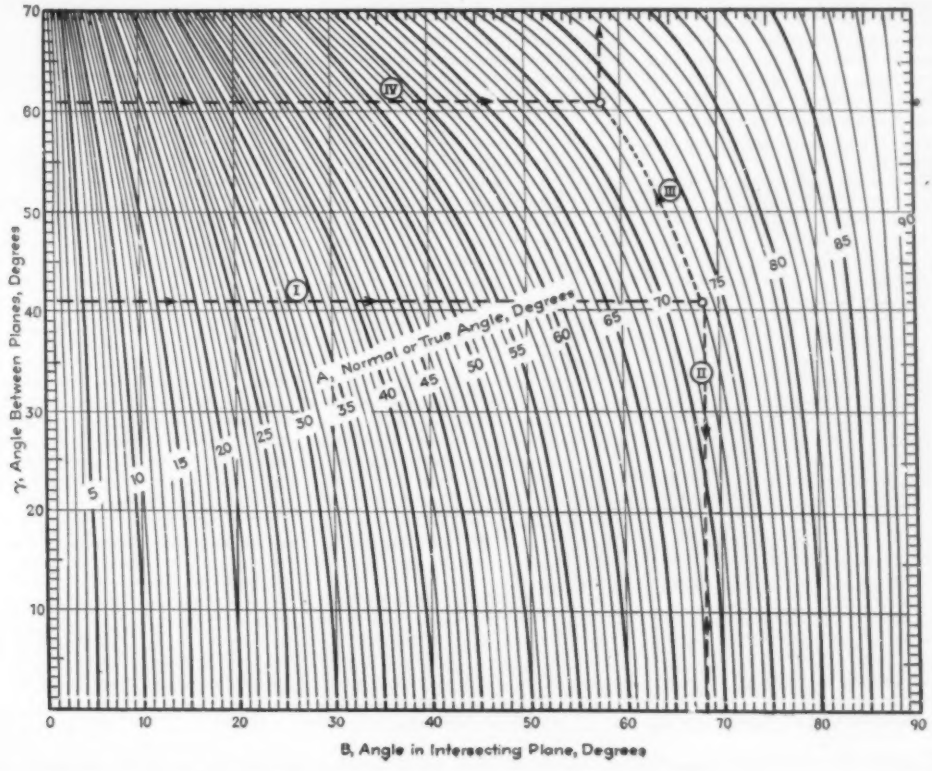
For example, if angle A is 73 deg and γ is 41 deg, find the angle which would exist in the intersecting plane Y-Y. Referring to chart and projecting line I to A scale establishes line II which determines B as 68.2 deg.

Another way to use this chart is in finding the true angle A, having measured an angle in a plane which is rotated γ deg from the normal. Here the reverse procedure would be followed: the intersection of lines (II and I) from B and γ would give angle A in the normal plane.

Given an angle B in a certain known plane (Y-Y), this graph may be also used to determine the increase or decrease of that angle when revolved θ degrees into another plane (Z-Z). This is illustrated in Fig. 2. In this case, it is necessary to first find the angle A in the normal plane (X-X); then with the previous data, angle C is found by considering the angle between planes as ($\gamma + \theta$) or 61 deg. From lines III and IV, C is found to be 58 deg.

FIG 2





Involute Chain Drive Has Twice Normal Capacity

A power transmission chain drive reported to have a transmission capacity of from 2 to 2½ times that of conventional chain drives and to be capable of operation at surface speeds up to 6,500 rpm and rotational speeds of 3,600 rpm has recently been announced for high-speed heavy-duty applications. Other advantages claimed for the new drive, as compared to conventional roller and silent chains, are greatly reduced operating temperatures, smoother and quieter operation, and operation under less strain and vibration. Designated the "Hy-Vo" drive, it is intended for transmission from engine and motor drives in industrial equipment and for replacement of chain or belt drives in steel, mining, chemical, petroleum and numerous other industries.

Performance and endurance are attributed to several factors:

1. An involute form on the sprocket teeth that promotes smoother chain engagement and reduces chordal slap or polygan effect. This lessens shock loading and high stresses in the chain links.

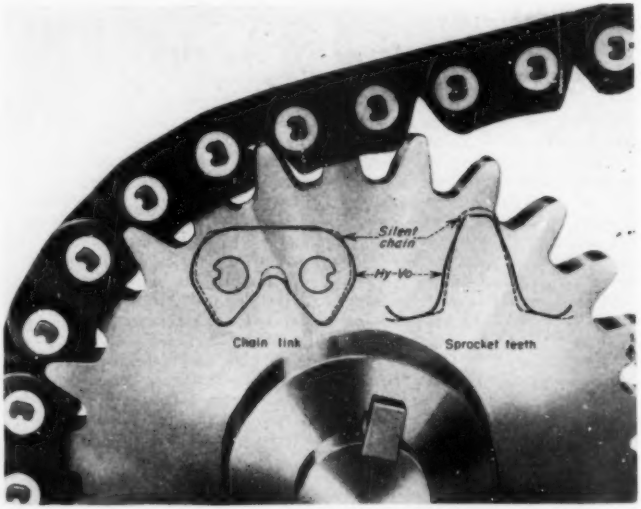
2. A compensating rocker chain joint to automatically shift the pitch line during articulation and thus minimize slippage and wear.

3. A balanced chain link designed with greatly improved stress distribution.

4. A new alloy link and pin material developed to insure strength uniformity.

5. Utilization of manufacturing processes new to the chain drive field —including shot peening—to improve fatigue resistance.

The basic and distinctive difference, however, between Hy-Vo and conventional chain drives is in the three points relating to its design characteristics. In operation, the chain is always tangent to the sprocket on the pitch circle. This is not true in the conventional chain drive, in which several actions take place that cause wear, fatigue and vibration: Flexing or joint articulation; impact between the chain and sprocket as the sprocket picks up each link; chordal rise and fall of the chain caused by the sprocket polygan; and linear pulsation or vibration, which is a direct result of chordal rise and fall.



DESIGN OF THE CHAIN DRIVE embodies entirely new principles. Sprocket teeths (right) have an involute profile while the chain link has additional metal in the critical area of the line of pull. Result is absence of chordal slap and smoother engagement, and consequently higher speed and load ratings.

In the new drive, the sprockets engage the teeth with conjugate action. During chain articulation, the compensating rocker joint shifts the pitch line automatically to maintain a constant effect radius and thus a constant linear speed. Consequently impact on engagement is lessened and chordal rise and fall are eliminated—two limiting factors on load and rotational speed.

Pitch elongation or stretch has been eliminated to the extent that it is virtually unnecessary to provide any means of take-up, making the drive applicable for engine compounding or heavy-duty power transfers where center adjustment is impractical.

Maximum velocities are 6,500 rpm for intermittent service and 5,600 rpm for continuous service; most efficient speed is between 4,000 and 5,000 rpm, when the efficiency of transmission is over 99.5 percent. Capacity ratings are based on a nominal service life of 20,000 hr.

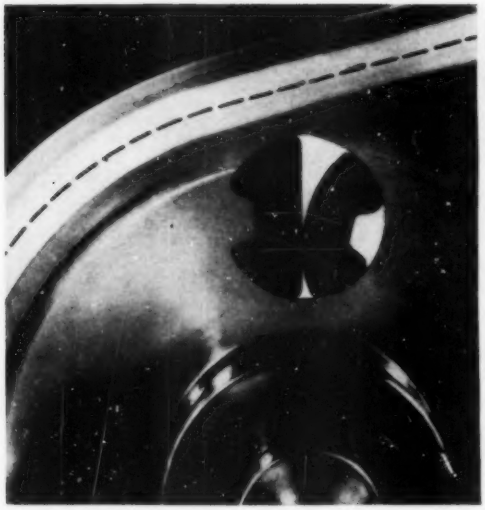
Development engineers report that Hy-Vo drive gives industrial users, and engine and motor designers, a power transmission drive that will allow them to develop and use smaller and less expensive power plants for many types of equipment. Such plants previously had been ruled out because high speed power transmission equipment was not available.

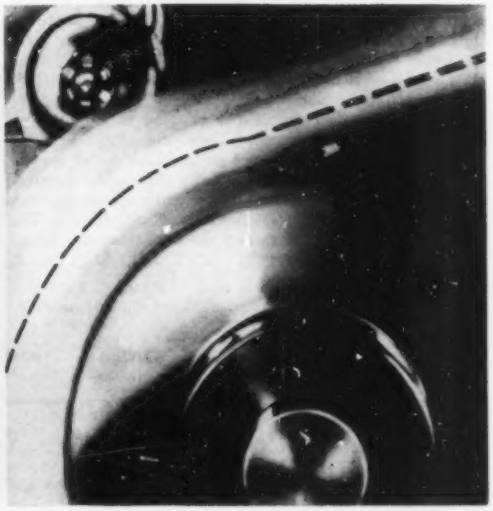
At present Hy-Vo Drives are being produced in one-inch, one-and-one-half inch and two-inch pitches, in the most-demanded chain widths. The current critical shortages of necessary materials have made it necessary to restrict orders to those with defense or essential ratings during the present emergency period.

Morse Chain Co., 7601 Central Ave., Detroit 8, Mich.

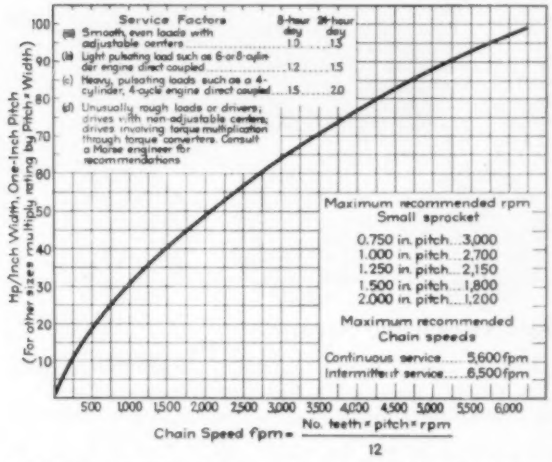
MATERIALS - PARTS

SPECIFIED BY PRODUCT ENGINEERS

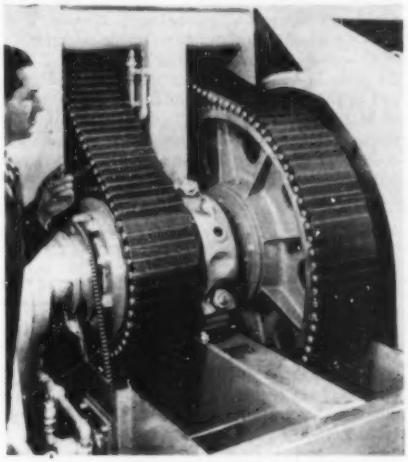




HOW ACTION OF HY-VO DRIVE compares with that of a conventional roller chain. Because pitch of the chain is gradually elongated, as it articulates in engaging the sprocket, linear speed of the chain is constant due to reduced polygan effect. Left, Hy-Vo drive, right, roller chain drive. The Hy-Vo chain is seen to be tangent to the sprocket on the pitch circle, whereas the conventional drive takes several actions. Insert in left photograph shows rocker joint of link.


Service Factors
8-hour day
24-hour day
(a) Smooth, even loads with adjustable centers 1.0 1.5
(b) Light pulsating load such as 6-or 8-cylinder engine direct coupled 1.2 1.5
(c) Heavy, pulsating loads such as a 4-cylinder, 4-cycle engine direct coupled 1.5 2.0
(d) Unusually rough loads or drives, drives with non-adjustable centers, drives involving torque multiplication through torque converters. Consult a Morse engineer for recommendations
Hp/Inch Width, One-Inch Pitch (For other sizes multiply rating by Pitch × Width)
100
90
80
70
60
50
40
30
20
10
Maximum recommended rpm Small sprocket
0.750 in. pitch...3,000
1.000 in. pitch...2,700
1.250 in. pitch...2,150
1.500 in. pitch...1,800
2.000 in. pitch...1,200
Maximum recommended Chain speeds
Continuous service.....5,600 fpm
Intermittent service.....6,500 fpm
500 1,000 1,500 2,000 2,500 3,000 3,500 4,000 4,500 5,000 5,500 6,000
Chain Speed fpm = No. teeth × pitch × rpm / 12

CAPACITY RATINGS of the new chain drive, which is based on an anticipated life rating of 20,000 hr. Recommended applications are to high speed heavy duty equipment or to equipment on which compactness of drive is essential. Increased efficiency and reduced transmission costs are claimed where single motors or engines above 100 hp are used.



TWO 2 IN. PITCH 12 IN. WIDE DRIVES transmit 1500 hp at 600 rpm in the diesel-electric drilling rig manufactured by Ensco for Standard Oil of California. A Hy-Vo drive 2 in. wide is capable of power transmission up to 500 horsepower.

Circle No. 1 in Reader's Service Card

CONTINUED ON PAGE 190

Batch Quantities Counted at High Speed

Continuous automatic counting of preselected batch quantities at high speed without interrupting production and without missing a count is achieved by an improved automatic batch counter. This counting instrument automatically operates a built-in control switch at completion of each batch count and at the same instant readjusts to start counting the next batch quantity.

The batch control switch may be used to start or stop electrically-operated machinery, conveyors, signals, kickout devices or other arrangements for marking or separating batches and warning operators. Being electrically operated, the batch counters will count any object or motion that can be arranged to operate a circuit-breaking device. The counter may be located at any distance from the actual source of count and operates on 115 v, 25 to 60 cycles a-c.

Production Instrument Co., 702-10 W. Jackson Blvd., Chicago 6, Ill.

Circle No. 2 on Reader Service Card

Pressure Cells Are Acceleration Insensitive

Four SR-4 pressure cells in capacities up to 100 psi have been redesigned to make them insensitive to linear acceleration and to position. Capacities of these cells, known as Type *E*, are 10, 20, 50 and 100 psi. Their operation is based on SR-4 resistance wire strain gage measurement with four-arm Wheatstone bridge. Measuring range extends from absolute vacuum to full rated pressure, except in standard units of lowest capacity for which the range is limited to ±10 psi. Pressure cells meeting other requirements are made to order.

There are two types of cells: Type ES321 cells have all parts in contact with the pressure fluid made of type 321 stainless steel. Type EMB cells have pressure bellows of Monel and brass pressure fittings leading to the bellows. Pressure connections for each are through a standard ⅛ in. male pipe thread. The maximum temperature for full accuracy in continuous operation of these cells is 150 Fahrenheit.

Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

Circle No. 3 on Reader Service Card

Precision Sub-Miniature Motor

Sub-miniature motors, designed for 60 cycle, 400 cycle, or variable cycle operation are now available in sizes from 1/1000 to 1/50 hp for continuous duty, and can be supplied for ambient temperature operation up to 100 C. Induction or synchronous types can be obtained for single or polyphase power input. Applications are for fan and blower drives in electrical equipment, as well as for prime movers in timing devices, aviation cameras, and sine wave alternators in military equipment.

The manufacturer states that the motors are built to close tolerances to assure maximum input, that the rotors are precision dynamically balanced, and that shielded ball bearings are used. All units are designed to meet the important JAN specifications including the environmental test.

The motor is of a totally enclosed construction approximately 16 oz in weight, 1¾ in. OD by 2¾ in. The same type of motor self-cooled frame is 2 in. OD by 3 in. long.

Atlas Aircraft Products Corp., 1 E. 53rd St., New York 22, N. Y.

Circle No 4 on Reader Service Card

CONTINUED ON PAGE 192

Now-Automatic Lubrication System

SPEEDS...SIMPLIFIES...CUTS COST OF MACHINERY LUBRICATION!

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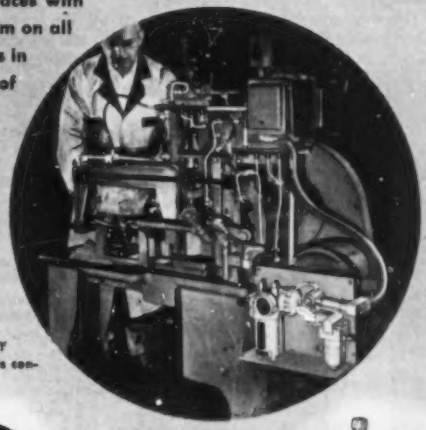
REG. U.S. PAT. OFF.

OIL-MIST

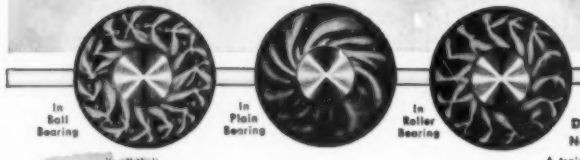
AUTOMATIC LUBRICATION SYSTEM

Unbelievably simple system atomizes oil into mist, distributes it through tubing to bearings. Bathes all bearing surfaces with fresh, clean, cool oil film. Uniformly maintains oil film on all sliding, rubbing, rolling parts regardless of variations in load, temperature or speed. No "peaks and valleys" of lubrication.

Fully automatic—eliminates waste and the uncertainties of the "human element." Extends bearing life as much as 17½ times. Seals bearings against dirt and abrasives. Cuts oil consumption as much as 90%. Greatly reduces the number of oils needed.



Eleven points on this automatic electric saw are served by Oil-Mist. Flexible lines carry lubricant to reciprocating and oscillating parts . . . condensing fittings apply liquid oil to a cam and roller . . . a spray fitting sprays oil on a drive chain, gear and sprocket. The lubricator is controlled automatically by the machine switch.



← OIL MIST

● You'll marvel that a system so simple—without any moving parts—can bring such a revolutionary change in the lubrication of machinery. Requires only two simple settings—to control the amount of air pressure and to regulate the density of the Oil-Mist. Once set, they need no further attention. Proved by plant installations on a wide variety of machines in many industries including steel, coal, food processing, chemicals, metalworking, textiles and woodworking. Get the proof yourself, with the Desk-Top Demonstration in your office, without obligation.

Alemite OIL-MIST Lubrication

DESK-TOP DEMONSTRATION

No obligation—Mail this coupon now

A trained Alemite Lubrication Engineer will give you the Desk-Top Demonstration at your office without obligation.

STEWART WARNER

Alemite, Division of Stewart-Warner, Dept. T-61
1850 Diversey Parkway, Chicago 14, Illinois

☐ Please have your Alemite Lubrication Representative arrange a desk-top demonstration of Oil-Mist. This entails no cost or obligation on my part.

☐ Please send me information about Oil-Mist by mail.

My name _____

Position _____

Company (leave blank if letterhead attached) _____

_____

Accessibility Features Clutch and Brake Unit

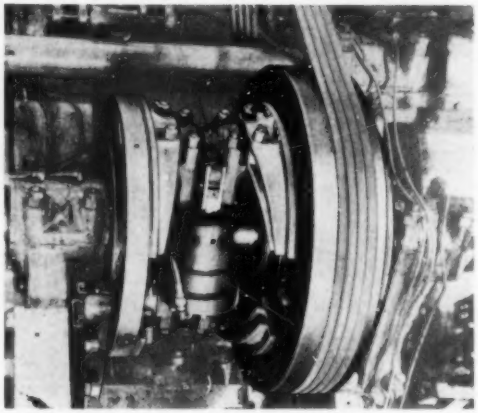
An air-powered combination friction clutch and brake unit, developed for medium and heavy machinery is designed for ready accessibility for repairs. Savings in downtime and maintenance labor are effected by the following:

1. Shoe and lining assemblies can be changed in a matter of minutes.
2. Such changes may be made without removing the unit from the machine.
3. All other wearing parts—driving mechanism, pistons, piston packings, springs—may be removed while the clutch is mounted on the machine, without the use of special tools and without the necessity of removing other parts.

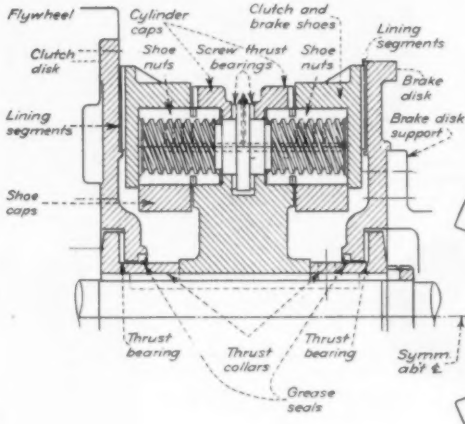
Disk scoring is limited because rivet heads cannot come in contact with the disks. Disks are bolted into place, instead of floating in teeth or splines. The basic actuating mechanism is so designed that linings are automatically withdrawn from contact with disks, eliminating drag. It is impossible for brake and clutch to be engaged simultaneously.

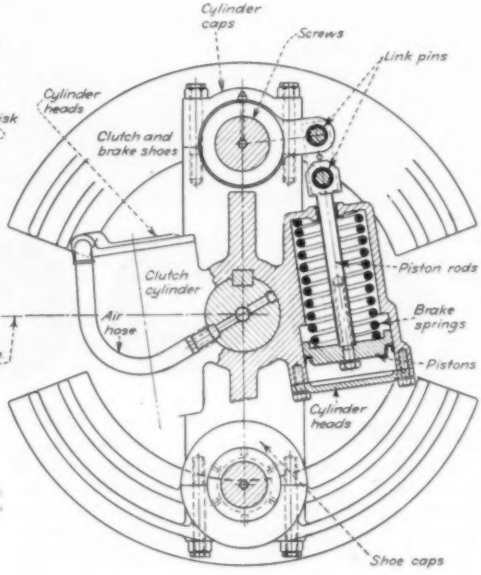
The unit can be used on presses of all kinds, power shovels, wire drawing equipment, slitters, marine drives, oil rigs, and paper, oil, rubber and rolling mills.

Power Presses, Inc., 615 Penton Building, Cleveland, Ohio



PNEUMATICALLY ACTUATED CLUTCH and brake unit in operating position on multiple station automatic press. Features are ease of maintenance and fail-safe operation if air supply is disrupted.





BASIC CONSTRUCTION FEATURES. To remove the shoes, it is necessary only to remove the clamp units and lift shoe out. Lining replacement can be made in a matter of minutes.

Circle No 5 on Reader Service Card

CONTINUED ON PAGE 194

Another First for...

N-A-X
ALLOY STEELS

The use of N-A-X ALLOY STEEL in Aircraft Gas Turbines saves up to 50 per cent of critical Stainless Steel.

Conservation is possible – without sacrifice with use of N-A-X ALLOY STEELS

With the demand for greatly increased quantities of the critical and strategic Stainless Steels used in Jet Engines intensified by the acceleration of the building program, the Air Force requested the producers of these engines to seek *suitable* material with less critical alloy content to replace the Stainless Steel for certain moderate temperature application in these aircraft gas turbines.

The steel selected had to be of low-alloy content with high strength and good welding characteristics. Ordinary low carbon steel did not meet the requirements because of its low tensile properties and the fact that it could not be satisfactorily welded by the inert arc process, which is widely used in aircraft gas turbine manufacture.

The data available from tests made on several weldable low-alloy, high-strength steels indicated that N-A-X ALLOY STEEL was the most satisfactory of the group — *its selection followed.* Unlike other possible substitutes, N-A-X ALLOY STEEL has good low temperature impact values, maintains its higher strength and is not subject to temper brittleness in the wide operating temperature range required of the steel for this purpose — from a low of −70°F. to +800°F.

The use of N-A-X ALLOY STEEL for this application has cut the amount of Stainless Steel required in half. This is of considerable importance to the Air Force.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division — Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

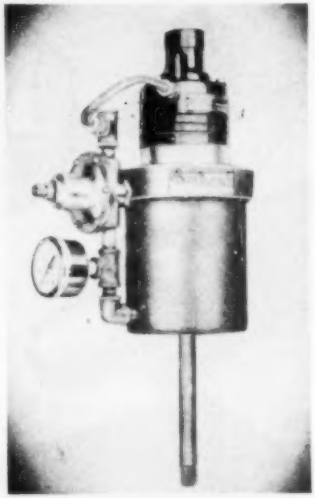
Piston-Type Pneumatic Operators Have Fast Response

Piston-type operators for pneumatic throttling control applications utilize a cushion loading principle, and are capable of repositioning accuracies well within the accepted standard of 1 part in 500 of total stem travel with high speed and stability.

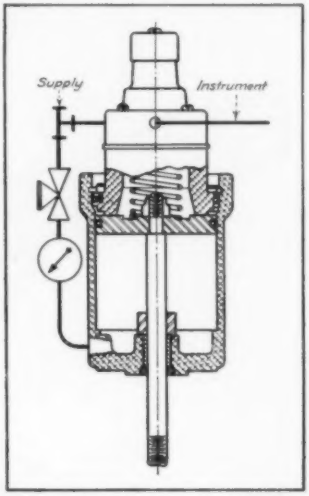
They consist of specially designed aluminum alloy cylinders, honed and polished to a high standard of interior finish, in which a piston, fitted with special "O" ring seals serves in place of the conventional diaphragms. A new built-in valve positioner capable of operating with supply pressures up to 100 psi replaces the side mounted positioner customarily used on spring motors.

Cylinders are available in 4, 6 and 8 in. dia with stem travels of 3 in. and 4 in. as standard. Their compact size, small air volume requirements, speed of response, long stem travel and high thrust capacity make them adaptable to control applications heretofore impractical to motorize because of the shortcomings of other types of operators. Speed of response is of particular interest. The 4 in. diameter cylinder, when powered with 100 psi operating air, is capable of exerting a 1,200 lb thrust through 3 in. of travel in 3 to 4 sec as compared to 15 to 20 sec with spring motors.

No tie-rods, bolted flanges, leather cups or conventional packing are used. All sealing is done with "O" rings both in the head closure and the piston proper. All "O" rings are graphite impregnated, resulting in considerably reduced friction and eliminating the need for lubrication.



PISTON-TYPE OPERATOR for throttling control operations involving long travel and a surplus of power. Speed of response is higher than for spring motors.



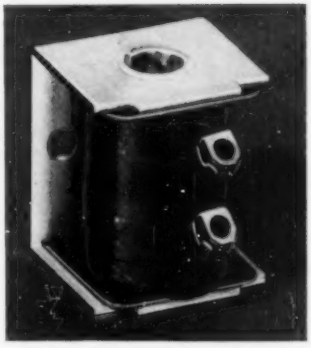
HONED AND POLISHED ALUMINUM CYLINDERS, and a piston with "O" ring seals that replace the conventional diaphragm are features of the positioners.

Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

Circle No. 6 on Reader Service Card

Valve Control Solenoid Resists Moisture

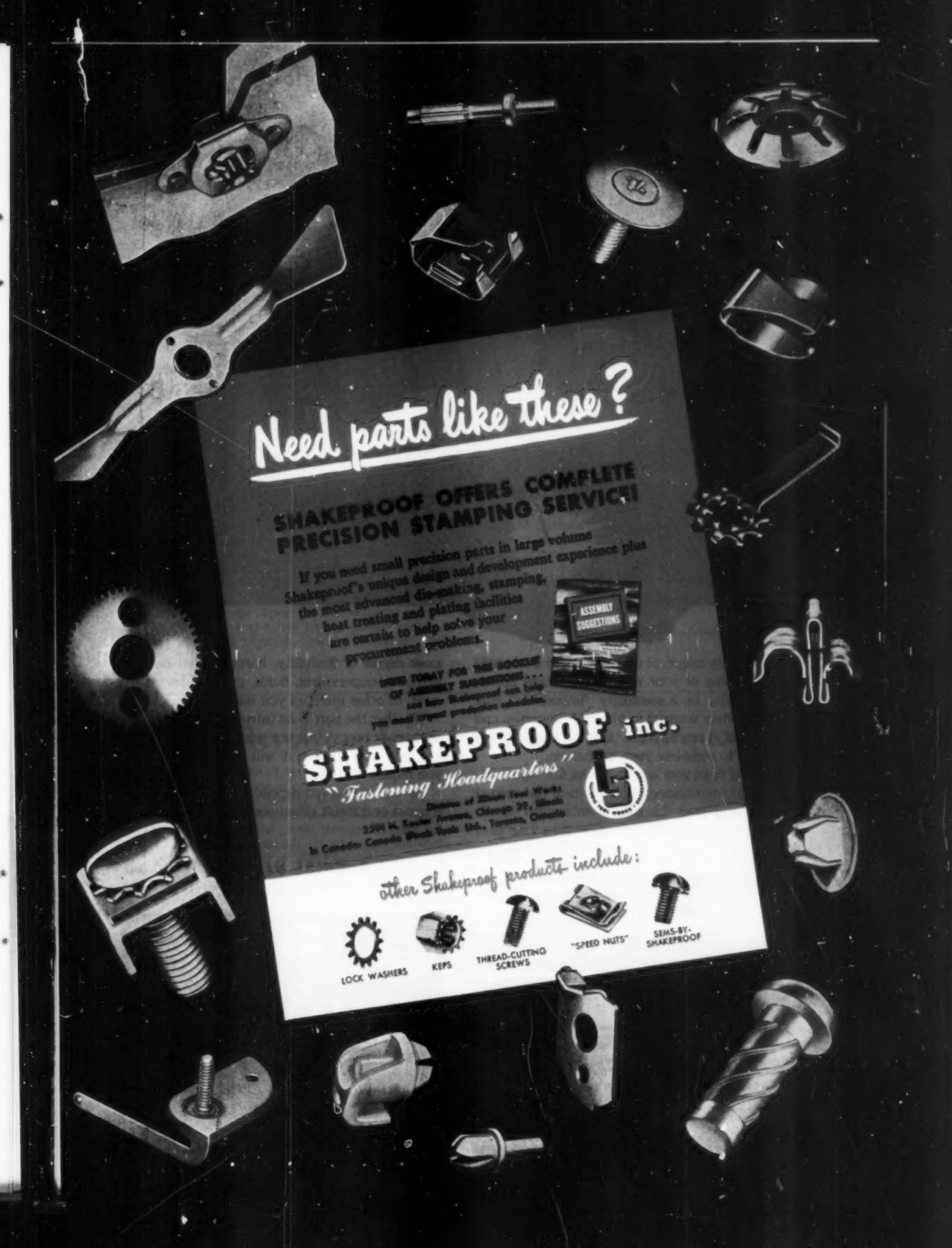
An inlet water valve control solenoid for automatic washing machines, and similar applications employs a newly developed nylon bobbin and is completely insulated throughout with silicone-varnished Fiberglas and Fiberglas electrical tape. Coil is wrapped with Fiberglas cloth and is then varnish-impregnated and redipped in a material which is completely impervious to the effects of water and detergent solutions, as well as oil, petroleum solvents and the harmful effects of extremely high humidity. Coil is normally used with Dole Valve No. DH4703, DH4503, or DH4403, but is adaptable to similar applications requiring the movement of a steel or stainless steel plunger with a $\frac{7}{16}$ in. O.D. brass sleeve. Coil requires an over-all space of $1\frac{1}{2}$ in. square by $1\frac{1}{4}$ in. depth, and is presently supplied with female connectors for bullet-type wire terminals, but may be furnished with leads or other means of circuit connections. The small size makes valves applicable where space is at a premium and normal water pressures are encountered. The silicone-varnished Fiberglas insulation gives protection against effects of elevated temperatures.



ETC, Inc., Niles, Mich.

Circle No. 7 on Reader Service Card

CONTINUED ON PAGE 197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SHAKEPROOF OFFERS COMPLETE PRECISION STAMPING SERVICE!
If you need small precision parts in large volume Shakeproof's unique design and development experience plus the most advanced die-making, stamping, heat treating and plating facilities are certain to help solve your procurement problems.
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WRITE TODAY FOR THIS BOOKLET OF ASSEMBLY SUGGESTIONS . . . see how Shakeproof can help you meet urgent production schedules.
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C/R

BLACK MAGIC

It's not really magic, of course. Simply a scientific understanding of your need for a critical pliable part. It may be a seemingly "impossible" part . . . completely unusual in physical properties and operational characteristics. But, it is a part you *must* find to complete your mechanism.

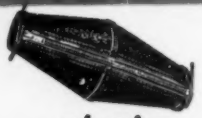
Working from your specifications, Chicago Rawhide's Sirvene engineers will produce the needed design, compound the right combination of oil-resistant elastomers, and mass-produce your part under strictest laboratory control. You'll have the *exact* degree of flexibility, hardness, resistance to extreme temperatures, fluids, gases, abrasion and wear, or other qualities you may require

Whether the part is an intricately designed diaphragm or boot . . . or is a simple but critical gasket, you may be sure it will function exactly as you require.

Sirvene has served dependably in thousands of unusual or difficult situations. It can do the same for you.

ENGINEERS: For basic information, write for your copy of "Engineering with Sirvene". There is no charge.

CHICAGO RAWHIDE MANUFACTURING CO.
1299 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois



sirvis

Mechanical Leather Products
Boots, diaphragms, packings and other products give dependable service under difficult operating conditions.

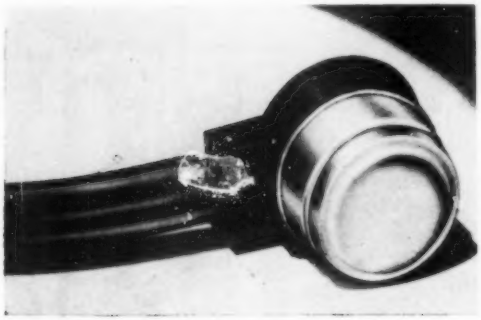
***PERFECT** Oil Seals*

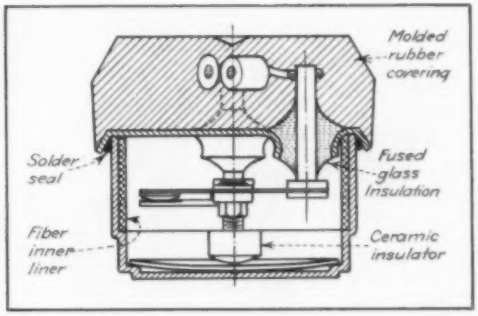
C/R seals are used in more motor vehicles, farm implements and industrial machines than any other shaft-type sealing device.

C/R
SIRVENE
THE *SCIENTIFIC* COMPOUNDED ELASTOMER

Boston • New York • Syracuse • Philadelphia • Pittsburgh
Cincinnati • Cleveland • Detroit • Peoria • Minneapolis
Kansas City • Houston • Los Angeles • San Francisco

Thermostat is Hermetically Sealed





New small snap-action, hermetically sealed disk type thermostats are weatherproof and waterproof. The terminals are brought out through glass seals. Rubber is bonded over the terminals and to the rubber covered leads. For extremes of temperature, silicone rubber can be used in the molding and on the leads.

Transmission of the temperature to be controlled to the disk thermal element within the hermetic enclosure is obtained by mounting the disk in the bottom of the metal enclosure where it closely follows the temperature of any surface on which the thermostat is mounted or of air or liquids to which the bottom of the thermostat is exposed.

The disk type snap-action gives a positive switch action which withstands vibration, shock and motion. Designed originally for electric refrigerator automatic defrost control, these thermostats are expected to have many uses in both military and civilian equipment.

The switch action may be either single or double throw, single pole. Contacts are protected from all contaminants by the hermetic enclosure into which an atmosphere of helium or other inert gas can be sealed when desired. Temperature settings are factory preset and are not thereafter adjustable. Differentials between opening and closing temperatures range upward from 15 F. Electrical ratings is 10 amperes, 30 v d-c and 125 v a-c, 3 amperes 250 v a-c.

Spence Thermostat Div., Metals and Controls Corp., Attleboro, Mass.

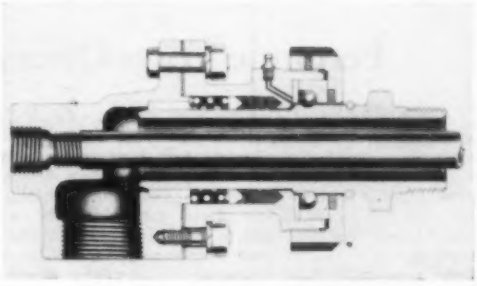
Circle No. 8 on Reader Service Card

Revolving Joint Features Low Torque

A compact, improved type of revolving joint for use in making piping connections to drum type dryers, rolls, calenders, and other rotating equipment has been introduced. The joint is characterized by extremely low torque, thus offering substantial power savings. Models are available for handling steam, oil, air, water, gas and chemicals.

The rotating portion of the joint consists of a special precision machined and heat treated steel tube which screws into the hub of the drum or roll. The non-rotating portion of the joint is ball bearing mounted on this tube. The specially designed ball bearings carry the load of both radial and end thrust. Use of a sleeve type pilot bearing at the end of the rotating tube insures alignment of the joint and provides a long bearing against twisting or cocking. Self-adjusting, self-sealing chevron type packing carried under light spring pressure provides a long life seal on the rotating tube. Low maintenance cost is assured since these new joints can be serviced, usually without even removing the joint from the roll.

These joints are built for 150 psi, steam, or 200 psi, hydraulic pressure, and also for vacuum service. They are



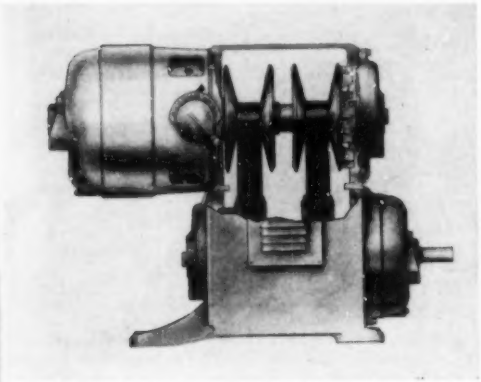
recommended for speeds up to 500 rpm, steam, or 750 rpm, hydraulic, and for temperatures up to 450 F, depending on packing specified. Standard sizes range from ½ to 2 in.

Barco Mfg. Co., Dept. J-29, 1301 Winnemac Ave., Chicago 40, Ill.

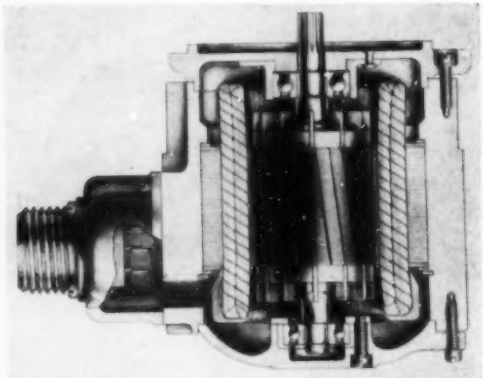
Circle No. 9 on Reader Service Card

CONTINUED ON PAGE 198

Varidrive and High Frequency Motors Announced



TWIN BELT DRIVES, a new belt tension device, and a line of extra heavy duty motors with ratings up to 50 hp are features of the modified variable speed drive.



HIGH-FREQUENCY EXPLOSION-PROOF INDUCTION MOTOR rated at 10 hp on 400 cycle a-c supply is completely sealed so that no sparks can be emitted.

A new line of extra heavy duty motors for a modified variable speed drive, and a high frequency explosion-proof motor for aircraft have been put into production.

The heavy duty motors with ratings as high as 50 hp will be used with a varidrive transmission. To carry the heavy load through the internaly speed changing transmission, dual Varibelts have been incorporated, thus distributing the load so that no undue strain is imposed. To counterbalance belt load, a tension control device has been designed that avoids the disadvantages of variable center drives or extra flexing of belts over idlers. A calibrated spring is employed to maintain pressure between the two halves of the driven disks and the sides of the belt. The spring takes up any slack that might be caused by stretch or wear of the belts. Use of dual belts is said not to affect the ease of changing motor speeds which is accomplished by merely turning a control dial.

The high frequency-explosion proof motor is of the inductive type. It is an addition to the line of high frequency aircraft motors from $\frac{1}{8}$ to 16 hp which have been designed and produced by this company.

U. S. Electrical Motors, Inc., 200 E. Slauson Ave., Los Angeles 54, Calif.

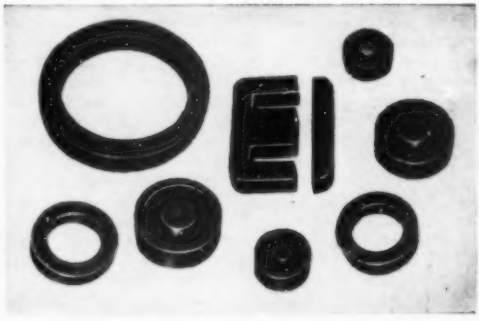
Circle No. 10 on Reader Service Card

Ferramic Cores Offer Range of Characteristics

A complete line of ferramic cores in cup, ring, or *E* and *I* types is now being offered. Ferramic is a new soft magnetic material that performs with high efficiency at high or low frequency. Outstanding characteristics include light weight, high permeability, high volume resistivity and low loss factor. Cores of this material can be extruded, molded or machined to the desired shape at relatively low cost. Laminations are not required, which reduces assembly time on components and simplifies design.

Ferramic cores can be supplied in a wide range of materials. Some properties of the Type A are maximum permeability, 57; saturation flux density, 840 gausses; residual magnetism, 615 gausses; coercive force, 3.7 oersteds; Curie point, 280 C; volume resistivity, 1 x 10^9 ohm-cm.

General Ceramics and Steatite Corp., Keasbey, N. J.



Circle No. 11 on Reader Service Card

CONTINUED ON PAGE 200

Customer Reports:

Asarco Continuous Cast Bronze Saves 20% in Metal Cost, Production Time

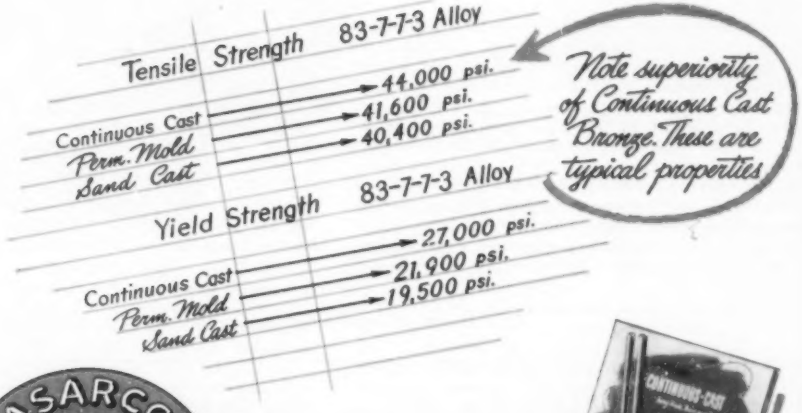
A manufacturer of packaging machinery tells of saving 20% in production time and 20% in material cost when he makes shaft bearings and nuts of Asarco Continuous Cast Bronze.

The patented Asarco casting process guarantees him bronze rod that is free from the hard and soft spots so often found in sand cast bronzes. Stock is exceptionally uniform and free from porosity. Since sand is not used, and dirt and dross are excluded, there can be no surface or internally trapped abrasive to dull tools or discourage high cutting speeds. Rejects are virtually unknown.

Dimensions are held to extremely close limits. For example, tube concentricities are within 1.5% of wall thickness. Dimensional uniformity is assured . . . machining on automatics is standard practice.

Continuous Cast Bronzes can be made to order in a wide variety of alloys . . . in standard lengths of 12′ . . . lengths 5′ to 12′ on request . . . lengths 12′ to 20′ on special arrangement.

216 sizes of standard Asarcon 773 bronze (SAE 660) are stocked in 105″ lengths for convenience at warehouses in all principal cities. Distributors will cut this stock long or short to suit your needs.


Tensile Strength 83-7-7-3 Alloy
Continuous Cast 44,000 psi.
Perm. Mold 41,600 psi.
Sand Cast 40,400 psi.
Yield Strength 83-7-7-3 Alloy
Continuous Cast 27,000 psi.
Perm. Mold 21,900 psi.
Sand Cast 19,500 psi.
Note superiority of Continuous Cast Bronze. These are typical properties

ASARCO CONTINUOUS-CAST RODS · TUBES · SHAPES ®

Send for this free catalog on Asarco Continuous Cast Bronzes. It contains physical properties, table of weights, photomicrographs, table of stock shapes and sizes and other data.

West Coast Sales Agent:
KINGWELL BROS. LTD., 444 Natoma Street, San Francisco, Calif.

American Smelting and Refining Company

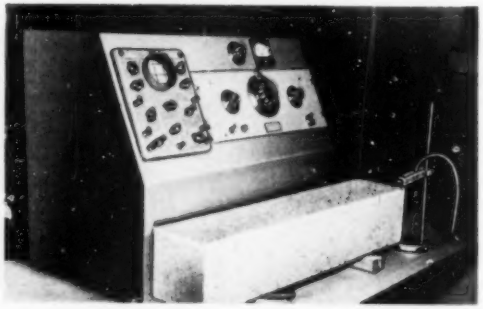
OFFICES: Perth Amboy Plant, Barber, New Jersey
Whiting, Indiana

Young's Modulus Determined By Sound Vibrations

A sonometer, developed from Portland Cement Association's basic design, is used for determining the resonant frequency of any solid mass of material where strength is an important factor, such as aluminum, carbon electrodes, ceramics, concrete, plastics, and steel beams.

The sonometer consists of two units; the control cabinet and the portable pick-up. The control cabinet contains an amplifier supplying 18 watts at the driving unit which permits accurate measurement of resonant frequency in solid masses weighing up to 1,500 lb.

An oscillator measures resonant frequency from 20 cycles to 22 kc. The phase relationship between the driving voltage at one end of the mass and various points within the mass can be determined and viewed on the screen of the cathode ray oscilloscope. This enables operators to determine the flexural and torsional modes of vibration. Information from these tests can be used to determine Young's Modulus of Elasticity.



Electro Products Lab., 4501 Ravenswood Ave., Chicago 40, Ill.

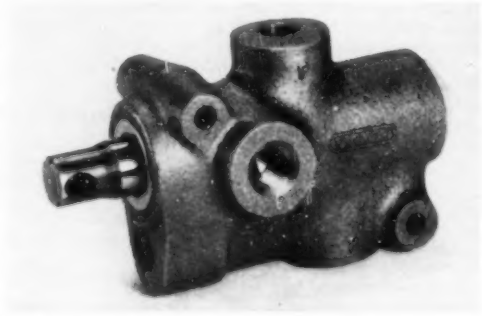
Circle No. 12 on Reader Service Card

Hydraulic Control Valve Suited to Heavy Duty Service

A low cost open center, single spool, three-way valve, based on models supplied for several years to individual equipment manufacturers, is now being made generally available.

Ideally suited to heavy duty service on farm implements and construction and materials handling machinery, the valve operates at pressures up to 2,000 psi and features an externally adjustable, built-in balanced relief valve sized to handle full pump capacity up to 14 gpm. Pressure drop through the open center of the valve is held to only 10.25 psi at 14 gpm, imposing a minimum load on an engine-mounted hydraulic pump and little loss in engine power while the valve is in the neutral or holding position. In addition to the raise, lower and locked holding position, a float position is also available on special order.

Cylinder and pressure ports are available in $\frac{1}{4}$ in., $\frac{3}{8}$ in. or $\frac{1}{2}$ in. internal pipe thread size, while the return port is sized at $\frac{3}{4}$ in.



The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio

Circle No. 13 on Reader Service Card

Hose Clamp is Self-Tightening and Self-Adjusting

A self-tightening hose clamp, whose spring tension also makes it self-adjusting to temperature changes has been recently developed.

To install this ring-type clamp, you simply squeeze the ends with pliers, slip the clamp over the connection, and release. The clamp exerts uniform pressure at every circumference point, allowing for irregularities in hose or pipe up to $\frac{1}{16}$ in. Shaped from rounded stock, the clamp does not cut into the hose. It can be disconnected as easily as it is installed, and can be re-used any number of times.

These self-tightening hose clamps are made in sizes to fit connections from $\frac{3}{8}$ in. O.D. through $2\frac{3}{8}$ in. O.D. They can be used with rubber, fabric or plastic hose conveying air, gases or liquids.

The manufacturer also offers special pliers that are recessed to fit the clamp lugs from either a vertical or horizontal position, thus further adding to the clamp's accessibility.

Corbin Hose Clamp Div., The American Hardware Co., New Britain, Conn.

Circle No. 14 on Reader Service Card

CONTINUED ON PAGE 202

13 YEAR TORTURE TEST
...STILL LIKE NEW!

QUAKER PACKINGS

Provide Positive Seal . . . Retain Flexibility Despite High Temperatures and Pressures

Here's a seat gasket cut from Ebonite Sheet Packing that rolled up thirteen years of trouble-free service on a pop-off pressure relief valve in a southern plant . . . withstanding high temperatures and pressures . . . eliminating leaks and shutdown time...assuring absolute safety. Only extensive changes requiring different sized gaskets made it necessary to replace this gasket at all!

Performance like this is made possible because of Ebonite's remarkable leak-proof characteristics and the fact that it will not carbonize, melt or become hard. That's why Ebonite is ideal for high pressure joints and flanges; for use with superheated steam, ammonia, brine, air, oils, acids, caustics, gases, hot or cold water.

For all your requirements—whether packings or belting for conveying materials . . . flat or V-belts for driving steam engines, steam turbines or electric motors . . . hose for flushing, suction, cleaning or fire fighting purposes—see your Quaker distributor, or write direct to us.

HOSE FOR RUGGED WEAR

Hose for air, steam, water, oil, gas or paints, Quaker makes it to fit the needs of the Chemical Industry. Each is pre-tested for peak performance.

BELTING FOR MAXIMUM HORSEPOWER

Flat belts or V-belts, Quaker has the one to fit the drive . . . to transmit maximum horsepower at the lowest operating cost . . . all pre-tested to assure peak performance.

QUAKER RUBBER CORPORATION • PHILADELPHIA 24, PA.

DIVISION OF H. K. PORTER COMPANY, INC. • Offices and Branches in Principal Cities

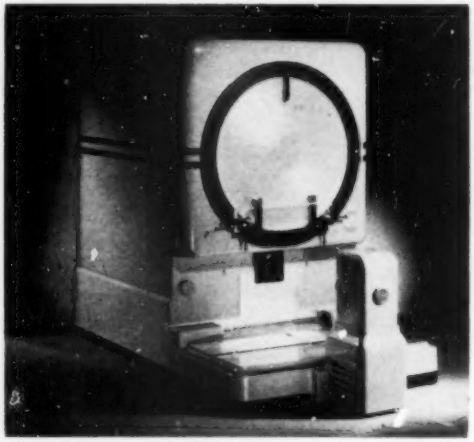
QUAKER RUBBER PRODUCTS
custom made for every industrial use

Optical Gaging Projector Utilized For Production

A projector has been designed to introduce optical gaging methods into production assembly and inspection. This unit projects a greatly enlarged shadow or a surface reflection of any object placed in its staging field onto a large illuminated screen and permits visual checking of the actual part against detailed drawing or other specification data previously placed over the viewing screen. It is specifically for use "on the line".

The wide application of this new machine to production and inspection purposes has been made possible by reducing the over-all size of the unit, and by using a unique optical system which allows a full unvarying eight inches of space between lens and object for all magnifications up to 100x.

The projector has an accessory by which light can be sent out of the same lens that picks up the image so that surfaces and deep recesses that cannot be shadow projected may be examined. Either surface or shadow projection is possible for objects facing toward the lens, up, down, to the left, or to the right.



Eastman Kodak Co., Rochester 4, N. Y.

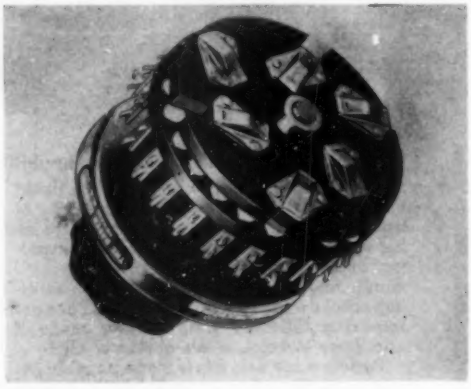
Circle No. 15 on Reader Service Card

Rotary Selector Switches Are Available In New Sizes

Long-life rotary selector switches are now available with up to 6 poles, 15 positions per pole, on each deck. This large number of poles and positions is made possible by a "knee-action" type of rotor arm, which is said to insure low contact resistance and uniform contact pressure for the life of the switches. Silver alloy contacts and rotor arms are used on all units.

Because of the great number of pole decks available, more compactness can be obtained than previously. This is in line with the present trend toward small size government equipment.

A roller-type detent, standard on all units, is claimed to give more positive action and longer life than heretofore obtained. Complete details on the pole arrangement, contact materials, general construction and applications of these long-life rotary selector switches can be obtained on request from the manufacturer.



Daven Company, 191 Central Ave., Newark 4, New Jersey

Circle No. 16 on Reader Service Card

A SELF-RETAINING PUSH-ON TYPE FASTENER to secure the oil baffle in an automobile engine has two small spring arms that snap into holes in the baffle, making the fastener self-retaining. Tinnerman Products, Inc., Dept. 14, Box 6688, Cleveland 1, Ohio.

SEALED VOLTMETER MULTIPLIERS are offered for use under severe humidity conditions. They can be used with commonly available one milliampere d-c instruments as well as with others. Sensitivities of 1,000 ohms per volt or more may be obtained. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

A BRASS FLARED TUBE FITTING has been designed to replace four previous types in the interest of standardization and saving of material vital to defense. This fitting has a 37 deg flare angle, dryseal pipe threads and a three-piece design. The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

CONTINUED ON PAGE 204

Designers' favorite for piping specs

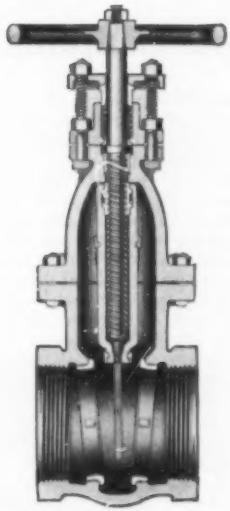
...your CRANE Catalog

You can't find a more complete selection of piping materials listed anywhere. Not only listed, but carefully arranged and cross-indexed to save you the bother of having to hunt for the items you need. Just remember, if it's piping, chances are it's in the Crane Catalog... and easy to find.

Other piping procedures, too, are simplified when you make Crane your one source of supply. In your plant, for example, product assembly operations go smoother. In the field, replacements are easier to get.

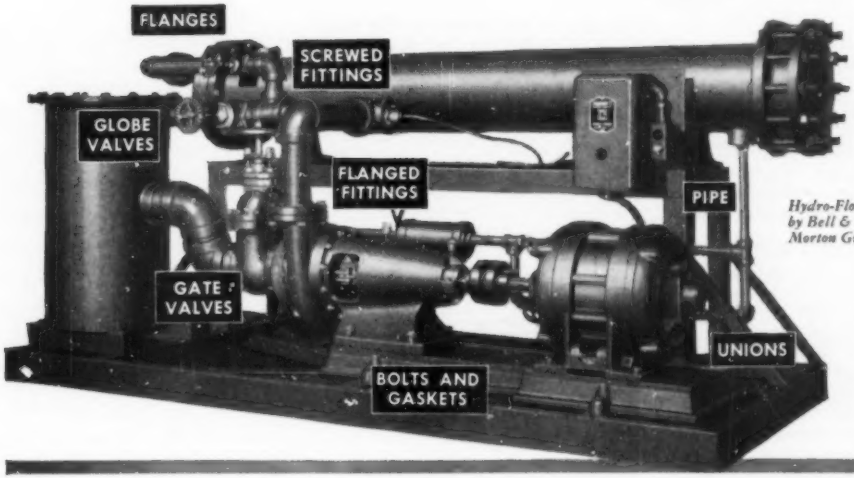
Most important to you, of course, is the fact that your product acquires added value in the eyes of your customers. They know from experience that Crane Quality in piping materials has never been surpassed.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas



FOR STEAM, WATER, OR OIL *lines Crane offers a wide selection of 125-Pound Iron Body Gate Valves, brass trimmed or all-iron, in patterns for every need. Shown here, Crane No. 460 with non-rising stem, screwed-in brass body seat rings, brass disc faces. Working Pressures: 125 pounds steam; 200 pounds cold water, oil, or gas. Sizes: 2 to 8-inch. Screwed ends. See your No. 49 Crane Catalog, p. 77.*

● FOR COMPLETENESS OF SELECTION ...YOU CAN'T BEAT THE CRANE LINE



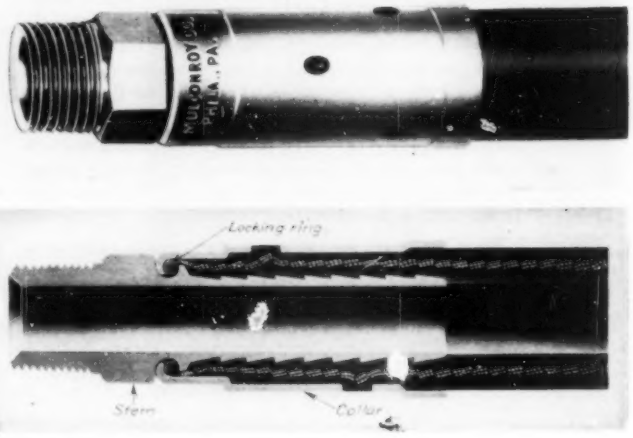
Hydro-Flo Oil Cooler, by Bell & Gossett Co., Morton Grove, Ill.

EVERYTHING FOR EVERY PIPING SYSTEM

CRANE

VALVES • FITTINGS • PIPE • PLUMBING AND HEATING

Hose Coupling Employs Unique Anchoring Principle



Through employment of a unique hose-to-coupling anchoring principle, this coupling has high strength, safety and efficiency.

The hose itself provides a major portion of the holding power through application of the principle that rubber in mass form, while not compressible, can be displaced under pressure.

The coupling consist of three parts: (1)-corrugated stem with wide hex section; male iron pipe thread (or special thread); collar to engage sleeve; (2)-sleeve extending full length of stem, with forward end shaped inward to engage stem collar and other end flared to assist flexing of hose; (3)-locking ring between collar and anchoring flange of sleeve.

In attaching the "Press-Lock" coupling, extreme pressure is applied to the above assembly, resulting in the shaping of the sleeve, ring and nipple into a solid unit; and in displacement of the entire hose wall.

The effect of this displacement is to create a three-way locking arrangement within the coupling—gripping of inner part of rubber mass to corrugations on stem; anchoring of outer portion in sleeve apertures; and multiple protrusions of internal wire braid, making it impossible for the hose to pull out of the coupling.

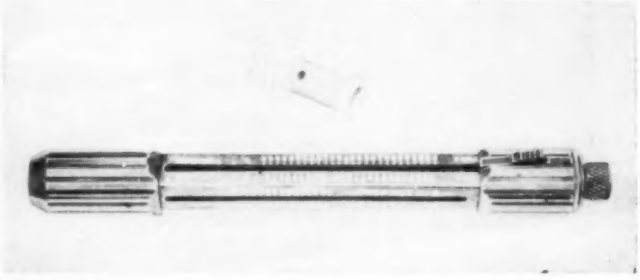
Engagement of forward end of sleeve over collar back of hex portion completes the powerful, blow-off-proof grip on the hose.

Made of steel, in sizes to fit hose from $\frac{3}{16}$ to 2 in., I.D., and available in connection with Mulconroy Hydraulic Hose Assemblies, or attached at factory to customer's hose.

Mulconroy Co., 5313 Jefferson St., Philadelphia 31, Pa.

Circle No. 17 on Reader Service Card

Hardness Tester Used Nylon Retainer



Bearing retainers machined from nylon bar stock contribute to the accuracy and durability of this portable hardness tester.

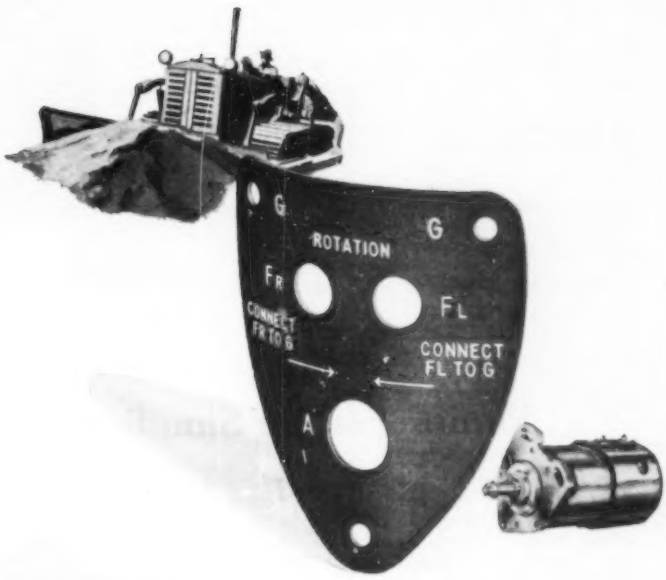
The tester called the "Metalometer", contains a hardened steel rod which is locked in position when raised by the knob at the top of the tester. Release of the trigger just above the hammer release the plunger, which rebounds from the surface of the metal being tested. At the highest point of rebound, the plunger is locked in position and permits hardness readings on the Rockwell *C*, Rockwell *B* and Brinell scales.

Locking of the plunger following its rebound is produced by the use of three steel balls in a retainer machined from FM-10001 nylon rod. Principal reason for using nylon is the material's excellent anti-friction characteristic, which prevents the instrument from becoming inaccurate due to friction on the plunger. In addition, nylon requires no lubrication and is not affected by various shop cleaning fluids.

Peabody Industries Inc., Highland Park, Mich.

Circle No. 18 on Reader Service Card

CONTINUED ON PAGE 206



How to move mountains—non-stop

When it comes to moving mountains—or spreading the landscape around—you can't beat bulldozers.

You can, however, beat a bulldozer if you put into it a part that can't stand the gaff.

An example is the generator. Vibration, abrasive dust, weather, shifting stresses and stray oils or greases are constantly taking their hardest licks at it. It leads a tough life.

That's why American Bosch Corporation, makers of dust-proof, heavy-duty generators for industrial tractors and bulldozers, selected Synthane laminated plastics for the insulation plate shown above.

Synthane is a material for industry. It possesses an unusual *combination* of physical, mechanical, chemical and electrical properties.

Synthane is light, strong, dense, abrasion resistant. It is easily machined or produced in formed shapes. Dielectrically strong, it is a natural for electrical applications. Synthane is corrosion and fungus resistant, chemically inert, stable over a considerable temperature range.

If this capsule description of Synthane excites your imagination, send for the complete Synthane catalog. Synthane Corporation, 3 River Road, Oaks, Pennsylvania.

PLASTICS WHERE PLASTICS BELONG

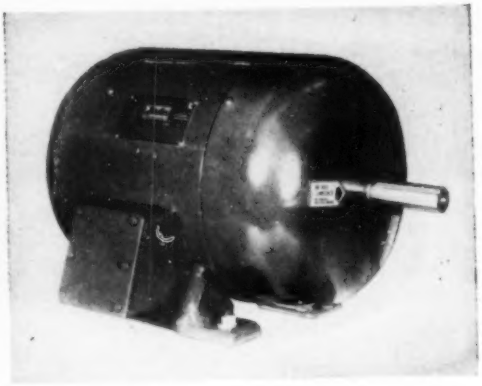
SYNTHANE

Food Industry Motor is Splashproof

Improved splashproof motors have been designed for food industry applications where splashing or hosing down exceeds NEMA standards for splashproofing. These motors incorporate gasketed cast iron conduit boxes with provision for attaching waterproof conduit. Motor windings are given multiple dips and bakes in moisture resistant thermoset varnish.

Baffles inside the rear splashproof hood and neoprene seals on the shaft outside the splashproof housing give protection against the entrance of water into the hood and the bearing housing. Grease seals are located between the outer periphery of the brackets and the splashproof hoods for added protection.

These motors available in frames 326 and smaller, use prelubricated ball bearings. No further lubrication is claimed necessary for the life of the bearings. Lubrication wells are also eliminated.



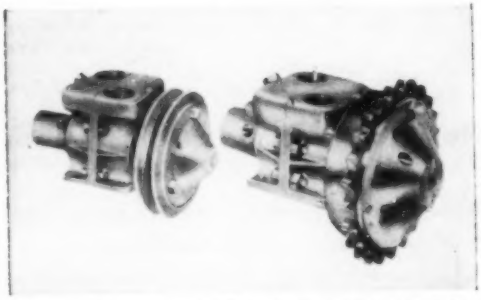
Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa.

Circle No. 19 on Reader Service Card

Pumps Feature Simplicity and Versatility

Now being marketed is a ball bearing pulley drive pump and a ball bearing sprocket drive pump, constructed so that lower transmission loads are absorbed by the pump housing without being transmitted to the pump shaft bearings. The drives are prepacked with lubricant and are fully sealed and shielded.

These pumps are available in Naval bronze forgings or stainless steel precision castings with capacities from $\frac{1}{10}$ to 19 gpm for use at pressures up to 150 lb per sq in. They are reversible, operating in either direction without loss of efficiency and bearings require no lubrication. The pumps are available in four sizes, $\frac{1}{4}$ in., $\frac{3}{8}$ in., $\frac{1}{2}$ in. and $\frac{3}{4}$ in., with speeds from 300 to 3,400 rpm. Both the ball bearing pulley drive pump and the ball bearing sprocket drive pump are available with hydraulically balanced built-in by-pass, and adjustable base. An important feature of these pumps is their simplicity, permitting any moving part to be easily replaced. Their versatility puts them in great demand wherever liquids and viscous fluids are moved, in every branch of industry for production and laboratories; in homes for water systems; on farms for spraying, etc; in carbonator and air conditioning industries, as vital parts on steam cleaning equipment; for marine use; for handling chemicals; on original equipment and for replacements wherever efficiency, quiet and long life are essential.



Eco Engineering Co., 12 New York Ave., Newark, N. J.

Circle No. 20 on Reader Service Card

DUCTILE BISMUTH WIRE AND RIBBON permits useful application of a material possessing unique electrical properties. It will present many development possibilities in the control and instrument fields. Fitzpatrick Electric Supply Co., 444 Irwin St., Muskegon, Mich.

SELF-ADHESIVE FELT finds considerable acceptance in industrial applications. This material is available in tape, spot washers and special shapes and will adhere to wood, metal, plastic, glass or other clean surface under finger pressure. J. B. Dawn Products, 3905 W. 64th St., Chicago, Ill.

THREAD COATING COMPOUND eliminates galling when used on threads, studs, and on junctions of metal surfaces subjected to temperatures up to 1,800 F. This compound leaves a deposit of copper between the metal surfaces. Felt Products Mfg. Co., 1504-14 Carroll Ave., Chicago, 7, Ill.

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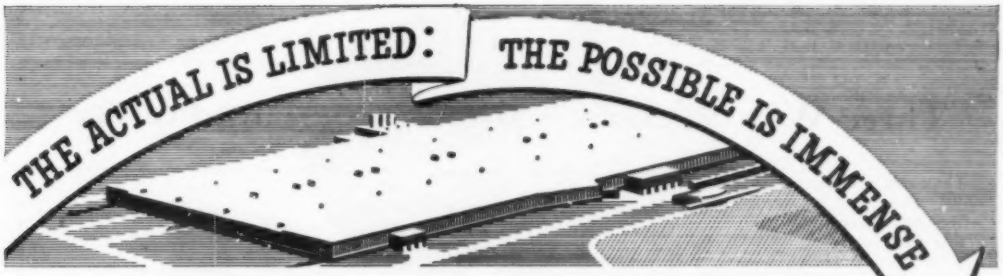


NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LE Co. 1951

FLEXIBILITY IN MANUFACTURE MEANS LOWEST COST PER PIECE

Products designed to utilize the economies of welded steel can be manufactured at lower cost regardless of quantity produced. Any product design can be developed from an unlimited combination of steel shapes to suit the type of manufacturing equipment available.

Each of the tee sections shown has been designed to withstand equivalent loads. As quantities of production increase and brakes, shears and forming equipment become advisable, less material is, of course, required and the amount of welding itself can be reduced.

Your Lincoln Welding Engineer will gladly explain how your products can be simplified and fabricated at lower cost using welded steel construction. Simply write The Lincoln Electric Company, Cleveland 1, Ohio.

Fig. 3. Angles, brake formed from plate, have better dimensions to withstand loading. Section requires only light, intermittent welds. Costs 30% less than Figure 1.

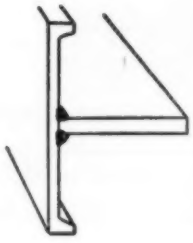


Fig. 4. Tee section fabricated from light channel is automatic Lincoln-welded to plate cut to shape by high-speed equipment. Gives better material distribution. Costs 35% less than Fig. 1.

Fig. 5. For higher quantity production, tee can be brake formed as a single piece from sheet and automatically Lincolnwelded at top. Weighs 30% less than Figure 1 . . . costs 40% less.

the ACTUAL

Fig. 1. Tee section fabricated in small lots by welding standard angles back to back. Requires only hack saw and welder.

increasing the YIELD

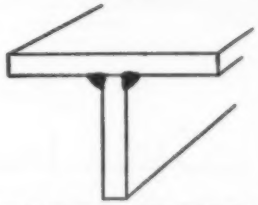


Fig. 2. Tee section for medium quantity lots for the shop having shear or flame cutting equipment. Costs 25% less than Figure 1.

the IMMENSITY of the POSSIBLE

Economical production regardless of quantity

SEE HOW WELDED STEEL IS FABRICATED AT LOW COST

Machine Design Sheets free on request to designers and engineers. Write on your letterhead to Dept. 36.

THE LINCOLN ELECTRIC COMPANY

CLEVELAND 1, OHIO

Three-Way Solenoid Valves Have Many Features

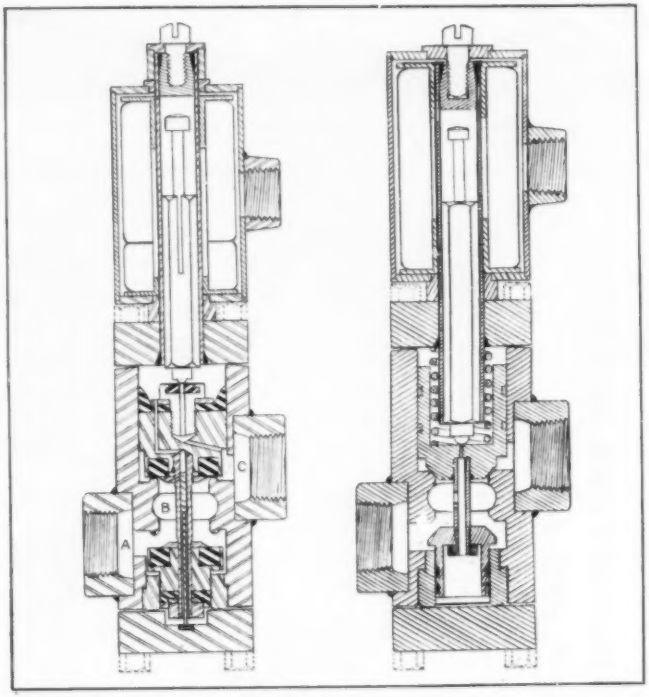
Three-way electro-hydraulic solenoid valves can be used for steam, air, oil, refrigerants and corrosive liquide. Fabricated from bar stock, they are available in brass, cold rolled steel and various stainless steel alloys. Features of these valves include (1) light weight, (2) capability of handling high pressures, (3) full opening of orifice through the valve seat according to pipe size, (4) low current consumption, (5) high temperature operation, (6) operation by momentary contact.

Valves are available in sizes from ½ to 3 in. inclusive. Solenoids can be wound for 24, 110, 220 and 440 v, 60 cycle a-c and for 6, 12, 18, 115 and 230 v d-c. A solenoid has been developed to withstand 500 F continuous duty. The ports A, B and C are visible in the cutaway views of two ¾ in. three-way valves shown here.

Weight of these ¾ in. valves is approximately 6 lb. Other sizes also have this light weight feature.

A more complete description and details of flow directions and operation of the three-way electro-hydraulic valves are available upon request from the manufacturer.

A. F. Hoppe Engineering, Inc., Greenboro, Ind.



Circle No. 21 on Reader Service Card

Portable Air-Meter is Light and Accurate

This portable air-meter, weighing only 11 lb, yet rugged and highly accurate measures air velocities of from 0 to 4,000 fpm and static air pressures of from 0 to 4 in. of water. The instrument has two scales for air velocity measurement; low range from 0 to 750 fpm and high range from 750 to 4,000 fpm. It has a self-contained battery power supply and operates from a probe-mounted, noble metal thermopile which is placed in the airstream whose velocity is to be measured. Measurement of static pressure is provided for by the use of an attachment mounted on the probe. The air-meter is not effected by the length of the cable from the probe to the instrument and is free from errors caused by sudden temperature variations. Lag of the instrument is less than one second.

Operation of the portable air-meter is simple. The probe is first connected to the meter. One switch turns on the power and adjusts the current set needle. The other switch selects either the low or high range scale. These two switches provide all adjustment for the unit. No additional adjustments or re-zeroing are required when switching from one range to the other.

Hastings Instrument Company, Inc., Super Highway at Pine Ave., Hampton 10, Va.

Circle No. 22 on Reader Service Card

CONTINUED ON PAGE 210

Other engineers are finding many new uses for this new SR-4® device . . . *How about you?*

Further expanding the engineer's field of exact knowledge, the Baldwin SR-4 Fluid Pressure Cell opens entirely new opportunities in the precise measurements of both stable and fluctuating pressures in all types of fluids.

Heart of the cell is a pressure-sensitive tube with an SR-4 strain gage grid bonded to its exterior. Gas or liquid to be measured enters this tube, causing it to expand, which stretches the fine wire in the grid. The consequent alteration in electrical resistance, calibrated in p.s.i. or other units, is measured by an indicator or recorder, or actuates monitor or alarm apparatus.

The cell is easily installed, and is adaptable to use with all types of fluids—corrosive or non-corrosive—and over a wide range of pressures. A wide variety of indicating, recording and controlling instrumentation is available to meet your particular requirement. Calibration inaccuracy is not more than ¼% of full range at any point from 0% to 100% of capacity, and this measuring performance is maintained under hundreds of thousands of pressure cycles. The unit is extremely responsive to pressure fluctuations making it invaluable for research on surges and similar pressure fluctuations, and explosion studies. For more detailed information, ask for Bulletin 306. One of our representatives will be glad to discuss the application of these cells to the solution of any fluid pressure measurement or control problem you may have.

BALDWIN BLH LIMA-HAMILTON

BALDWIN-LIMA-HAMILTON

TESTING HEADQUARTERS

EDDYSTONE DIVISION, BALDWIN-LIMA-HAMILTON CORPORATION, PHILADELPHIA 42, PA.

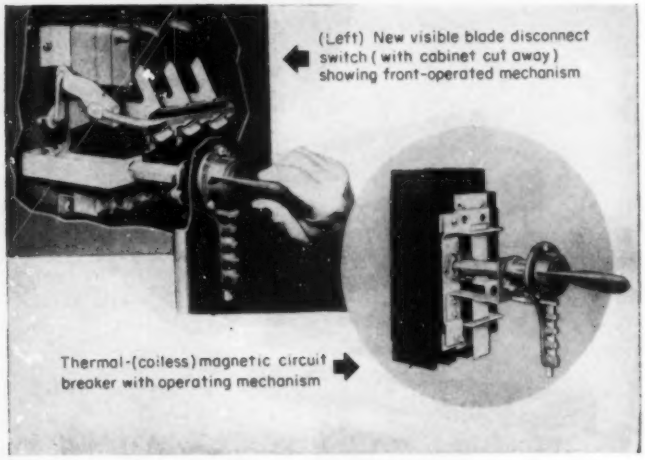
In Canada: Peacock Bros., Ltd., Montreal, Quebec

Disconnect Operating Mechanism Increases Safety

This operating mechanism for switches and circuit breakers meets the requirements of manufacturers who assemble their own control panels for machine tools or other electrically operated equipment. Designed for convenient mounting, it permits the disconnect (either switch or breaker) to be mounted directly on the panel without the use of posts or brackets. A coupling rod from the disconnect engages the separate operating handle assembly mounted on the door. A rubber gasket is furnished, which may be used in mounting the handle in NEMA 1A, V or XII cabinet.

Changes in the length of the coupling rod accommodate cabinets of varying depth. A built-in adjustment in the coupling compensates for errors in rod length or cabinet depth of $\pm\frac{1}{4}$ in. The mechanism can be used with switches mounted in cabinets having a depth of $6\frac{3}{4}$ in. to 14 in. from door to panel surface; or with breakers in cabinets measuring $6\frac{3}{8}$ in. to $13\frac{1}{8}$ in. from door to panel.

Interlocks and padlocking arrangements assure complete operator safety. The operating handle can be padlocked "off" with one, or as many as four, padlocks of varying sizes. With the handle locked, the door cannot be opened. An interlock also prevents opening the door when the switch or breaker is "on". However, authorized personnel, using a tool can release the door interlock and open the door without interrupting power.


(Left) New visible blade disconnect switch (with cabinet cut away) showing front-operated mechanism
Thermal-(coiless) magnetic circuit breaker with operating mechanism

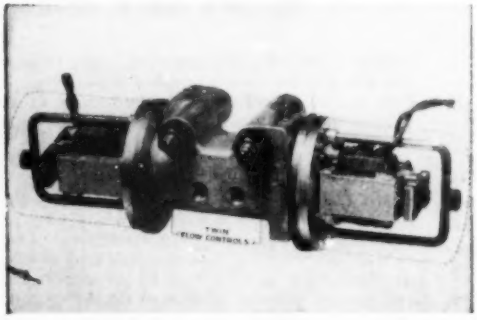
Square D Co., 4041 No. Richards St., Milwaukee 12, Wis.

Circle No. 23 on Reader Service Card

Double Solenoid Valve for Low Pressure Use

A double-operated solenoid valve has been designed for operation of double acting air and low pressure hydraulic cylinders where pressure must be held on one side of the cylinder for a given period of time. Also featured are built-in flow controls to govern speed of cylinder. The valve may be reversed by momentarily energizing a single solenoid and the cylinder stays in position without the necessity of holding either solenoid energized. Power failure will not reverse the valve or cylinder—a safety feature incorporated in this type of valve design. Corrosion resistant materials used in construction of the valve insure continued service.

Only moving part is a one-piece stainless steel spool that carries an "*O*" ring type seal. The valve may be base-mounted or pipe mounted directly to the body. A cap protects each solenoid from damage but is removable for servicing by removing the unitized type of mounted solenoid assembly which is threaded as a complete assembly to the main valve body. There are no springs, as the valve is operated directly by the solenoids. This new model called the DDS-4-375, is available in $\frac{1}{4}$ in., $\frac{3}{8}$ in., and $\frac{1}{2}$ in. full orifice area in two styles of mounting. Additional information on the mechanical features, specifications and industrial applications of these valves can be obtained from the manufacturer.



Airmatic Valve, Inc., 1643 E. 40th St., Cleveland, Ohio

Circle No. 24 on Reader Service Card

CONTINUED ON PAGE 212

This one is ordinary drawing brass

This one is "Formbrite"

And here's the difference

Formbrite is a trade mark of The American Brass Company designating copper-base alloys of exceptionally fine grain, combining unusual polishing characteristics with good strength and hardness, plus excellent ductility.

Now let's take 'em one by one. Formbrite is produced in sheet, strip, rod, wire and seamless tubes in most of the copper-zinc alloys. The process is applicable to practically any copper-base metal.

Its superfine grain is the result of special rolling or drawing and annealing techniques.

Formbrite in sheet and strip form is an excellent pressroom metal. It costs no more than ordinary drawing brass – yet it is harder, stronger and much more resistant to scratching and abrasion.

Despite its strength and "springiness," the ductility of Formbrite in deep-drawing operations will amaze you.

And here's the payoff: Parts made of Formbrite polish so easily and so quickly that often only a color buff is needed for plating.

Skeptical? Of course! So let's prove it. Write for the two cupped samples illustrated above in full size. Compare the finish, then try them out, side by side, on your own buffing or polishing wheels.

Address The American Brass Company, General Offices, Waterbury 20, Connecticut. 5109

ANACONDA

the name to remember in

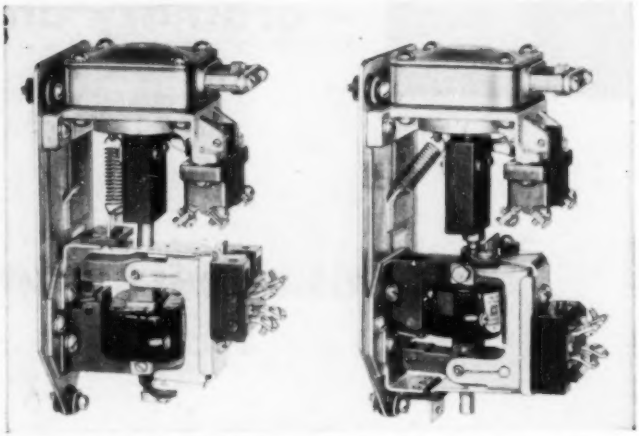
COPPER·BRASS·BRONZE

Pneumatic Timer Has Invertible Magnet

Designed for timing machine tool cycles, conveyor systems, and similar industrial operations, the Square D Class 9050 Type *R* pneumatic timing relay has a new invertible magnet that permits contacts to operate with delay either after energization or after de-energization of the magnet. The new invertible a-c magnet permits easy conversion from delay after energizing operation to delay after de-energizing, or vice versa; no extra parts are needed.

The timing range is adjustable from 0.2 sec to 3 min. Accuracy is within 10 percent and is independent of normal variations in voltage, ambient temperature, at atmospheric pressure.

Silver to silver, snap action contacts have pilot duty ratings up to 600 v, a-c or d-c. One or two additional electrical interlock units can be furnished. The timer is available in NEMA I, IV and VII enclosures. Type *R*, a-c timers (with invertible magnets) can be furnished with operating coils for voltages up to 600 v, 25 to 60 cycles.



(LEFT) Class 9050 Type RO-9E timer, assembled so that contacts operate with delay after magnet is energized. (RIGHT) Class 9050 Type RO-9D timer, with contact operation delayed after magnet is de-energized. Operation of both units is based on the principle of air transfer between two chambers through a restricted orifice.

Square D Co., 4041 No. Richards St., Milwaukee 12, Wis.

Circle No. 25 on Reader Service Card

Flat Wire Rings Improve Brazing Operation

Flat wire "no-tangle" notched-coil stress-relieved silver brazing and soldering rings for faster, more economical and improved brazing of armed forces projectiles and other ordnance equipment and supplies are now available. These flat wire preforms were especially designed for applications requiring larger volume of silver alloy for added strength in critical joints and where the depth and shape of the groove prohibited use of round wire rings.

Flat wire rings can be made in unlimited, job-determined diameters and wire thicknesses in butt, lap and gap form. Because they are flattened to individual job specifications, the rings are said to provide a more complete fill and a stronger, leak-proof bond. Stress-relieved rings retain ±0.001 in. tolerance under all conditions and do not distort or fall away from the work piece when heat is applied.

Rings are designed to eliminate spillage associated with hand-fed wire or conventional machine-wound rings. Precise fabrications of rings also minimizes rejects and the need for machining brazed parts.

Lucas-Milhaupt Engineering Co., 5051 So. Lake Dr., Cudahy, Wis.

Circle No. 26 on Reader Service Card

CONTINUED ON PAGE 213

NEED MORE DATA . . .

. . on New Components, Materials, and Parts?

. . on Products Appearing in the Advertising Pages?

WANT COPIES OF . . .

. . the latest catalogs and manufacturers' bulletins?

READER SERVICE

KEEP UP TO DATE

Every month Product Engineering describes in detail the most significant NEW developments in parts, materials, components, and products . . . and lists scores of NEW catalogs and bulletins available from manufacturers. To obtain additional information on these new products and to get copies of any manufacturer's bulletin of interest to you, use the postcards on these pages.

USE THIS CARD

- For further information on products described in the New Components, Materials, and Parts Department, circle the postcard number.
- For additional information on products advertised in this issue, fill in numbers of the pages on which the products are advertised in spaces provided on postcards. Use advertiser's initial if more than one advertisement appears on a page. Write in name if pages are unnumbered.
- For copies of any manufacturers' bulletins described on page 224, and following, circle postcard number.

PRODUCT ENGINEERING: *Not good after 8/1/51*

Please send me more information on the New Parts and copies of the New Bulletins identified by numbers circled below:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120

Advertising on pages

NAME _____ TITLE _____

COMPANY _____

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CITY _____ STATE _____ 4/51

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BUSINESS REPLY CARD

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Readers' Service Department

PRODUCT ENGINEERING

330 West 42nd Street

New York 18, N. Y.

READER SERVICE

KEEP UP TO DATE

NEW CATALOGS AND BULLETINS

NEW PARTS, MATERIALS, AND COMPONENTS

PRODUCTS APPEARING IN THE ADVERTISING PAGES

Getting ALL the information about ALL of the significant new developments in the design field every month is a tough . . . and time consuming . . . job. To save you time, the editors of Product Engineering screen hundreds of new products each month, select the outstanding ones, and check the manufacturer of each for additional information on construction, operation, and applications prior to describing them on the editorial pages. They scan scores of new catalogs and bulletins, present summaries only of the ones they know will be of interest.

The result is time saved . . . for you. All you have to do to get further information is to fill in the easy to use postcards on these pages. Product Engineering's Reader Service Department will do the rest. Note: Please reserve one of these cards for the engineer who gets the issue after you. He too is interested in new developments.

For new Catalog and Bulletins descriptions turn to Page 224.

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41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120

Advertising on pages

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE _____ 6/51

Pyrometer Controls Give Improved Readability

Automatic pyrometer controls with a 4½ in. meter give better readability and improved appearance. They can be set to the control temperature with more ease and greater accuracy and can be read at a greater distance. Construction improvements include heavier gage steel panels and cabinets, reinforced corners, and three point suspension to prevent pulling the cabinet out of shape when it is screwed down on an uneven surface. Plug-in connections between the control and the terminal board facilitate removal and replacement of the unit without disturbing any permanent connections.

These pyrometer controls are equipped with a switch to change from automatic to limit control. As a limit control it acts as a shut off or safety warning device which will make contact when a pre-set temperature is reached and sound an alarm or shut off a furnace. The contact holds until reset.

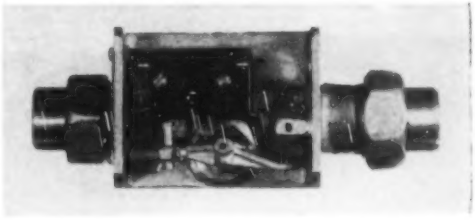
Assembly Products, Inc., Main at Bell St., Chagrin Falls, Ohio

Circle No. 27 on Reader Service Card

Water Interlock Has Improved Construction

An improved flow interlock, a device which responds to a flow of water to open or close an electrical contact, has a finer differential, union fittings at both ends, a bronze piston, reduced size and weight, simpler adjustment, and more wiring space.

In operation, the device closes a contact when a flow of water exceeds a preset amount and opens it when the flow falls below the preset amount. The interlock can be used as a safety device in many applications, including hot water heaters, welding units, kitchen waste units, transformer cooling, induction heating, television luminaires, and water-cooled dynamometers.



Only one screw adjustment is needed to set the circuit for any flow from one-half to four gpm. The flow differential between the cut-in and cut-out of the electrical contact is 0.1 gpm maximum. The interlock does not control the amount of water flow. This can be accomplished, if desired, by installing a throttling or regulating valve ahead of the device.

Electrical rating is 10 amps at 120 or 240 v, a-c. Maximum line pressure that the device will withstand is 125 psi.

General Electric Co., Control Div., Schenectady, N. Y.

Circle No. 28 on Reader Service Card

MIDGET BELLS, featuring a basically new principle in a-c contactless vibrating bell construction, are now being manufactured. Greater sound carrying power results from prolonged vibration of the bell shell. The bell is underdome, solenoid and plunger type. Signal Engineering and Mfg. Co., 154 W. 14th St., New York 11, N. Y.

A METAL CLEANER for surface preparation prior to painting removes rust, grease and oil and leaves an iron phosphate coating which is a firm bond for all types of paint. It is applied with brush or steel wool, wiped off with a cloth and allowed to dry 5 to 10 min prior to painting. Westville Lab., Monroe, Conn.

HIGH MEGOHM RESISTORS can be furnished with resistance values as high as 50 million megohms. These units are jacketed in polyethylene to provide maximum protection against mechanical damage and humidity. They are suited for electrometer circuits, radiation equipment and as high resistance standards in measuring equipment. Resistance Products Co., 714 Race St., Harrisburg, Pa.

PERMANENT MAGNETS using only non-critical materials are suitable for applications in radio and television receivers as well as other commercial and military equipment. Metallurgical Lab., Sylvania Electric Products, Inc., Bayside, N. Y.

CONTINUED ON PAGE 214

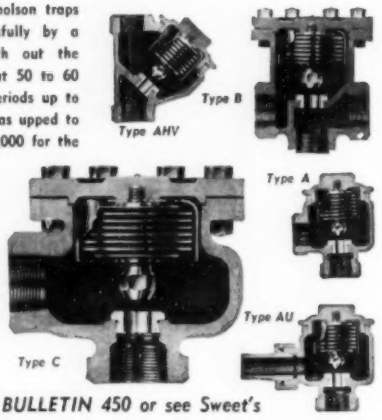
Large Processor Achieves

MORE UNIFORM HEATING CYCLES

with Nicholson Steam Traps

The positive action of Nicholson traps was recently used successfully by a chemical maker to smooth out the heating cycles of cookers at 50 to 60 minutes, against previous periods up to 105 minutes. Steam flow was upped to 3000 lbs. an hour against 2000 for the previous mechanical type.

5 TYPES FOR EVERY APPLICATION, process, heat, power. Sizes ¼" to 2"; pressure to 225 lbs. To learn why an increasing number of leading plants are standardizing on Nicholson thermostatic traps . . .



Send for BULLETIN 450 or see Sweet's

W. H. NICHOLSON & CO., 200 Oregon St., Wilkes-Barre, Pa.

WE TURN BLUEPRINTS into Action

Precision Gears Made to Your Exacting Specifications

When Sewall craftsmen go to work on your specifications, you are employing the extensive facilities of an experienced organization. Our engineers can give you valuable assistance in establishing the *one best design*—then in turning out uniform production runs. Illustrated are examples of a straight bevel gear and pinion . . . Zerol bevel gear and pinion . . . worm and worm gear . . . helical gear and pinion. *Send blueprints or samples for prompt estimates on any quantity.*

STOCK SPROCKET CATALOG ON REQUEST

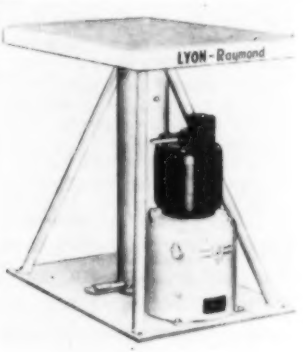
RACKS • SPROCKETS • SPUR • SPIRAL • BEVEL • ZEROL BEVEL • WORM GEARS

E. B. SEWALL MANUFACTURING CO.

696 Glendale St. St. Paul 4, Minnesota.

Power Pump Offered For Hydraulic Table

A ¾ hp motor-driven pumping unit is now being offered to speed the operation of a hydraulic elevating table requiring many cycles of elevating and lowering. The pump can be operated by either a pedal controlled foot switch or push button hand switch.



The unit has a self-contained oil reservoir and is supplied with either the conventional type or pancake type ball bearing motor with current characteristics to meet each customer's requirements.

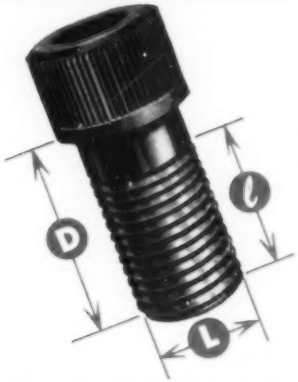
Lyon-Raymond Corp., 202-80 Madison St., Greene, N. Y.

Protective Coating Provides High Film Flexibility

High film flexibility and good adhesion and impact resistance are obtained with a new air-drying plastic protective coating. The new coating is used to protect tanks, tank cars, pipes, fittings, structural steel parts and chemical processing equipment against attack by splash, drip and spray from corrosive chemicals, corrosive atmospheres, weathering and rust. It is expected to find its broadest use in chemical processing, rayon and cellophane production, photo finishing, pulp and paper manufacturing, sewage disposal, filtering and electroplating and in mining operations. It cannot be used in food processing because it imparts a slight odor and taste.

This coating will not chip or crack and can be used on steel, aluminum, concrete, hardwood, or composition board. It is applied by spray, allowing one hour drying time between coats and 24 hours drying time after the final coat. No primer is required

"STANDARD" recommends STANDARDS*



Standard UNBRAKO thread lengths are computed from the following formulas: **"Thread length, l.**—A screw thread is measured from the extreme point to the last usable thread and shall be as follows:

For American National coarse.
- $l = 2D + \frac{1}{2}$ in. (where this length of thread would be greater than half the screw length).
- $l = \frac{1}{2}L$ (where this length of thread would be greater than $2D + \frac{1}{2}$ in.).

For American National fine.
- $l = 1\frac{1}{2}D + \frac{1}{2}$ in. (where this length of thread would be greater than three-eighths the screw length).
- $l = \frac{3}{8}L$ (where this length of thread would be greater than $1\frac{1}{2}D + \frac{1}{2}$ in.).

Screws too short to allow application of these formulas shall be threaded as close to the head as practicable."

(Quoted from National Bureau of Standards Handbook H-28)

★ **One of a series listing *Standard* UNBRAKO Socket Screw Products sold by your local UNBRAKO Distributor. If you want reprints of this and other advertisements in the series, ask for them on your business letterhead.**

SPS
STANDARD PRESSED STEEL CO.
JENKINTOWN 39 PENNSYLVANIA

UNBRAKO® SOCKET HEAD CAP SCREWS

Diameter	Threads per inch NC	Threads per inch NF	Length	Thread Length NC	Thread Length NF	Price per 100	Quantity per box
#4 (.112")	40		1/4	1/4		4.65	100
	40		3/8	3/8		4.70	100
	40		1/2	1/2		4.90	100
	40		5/8	5/8		5.10	100
	40		3/4	3/4		5.35	100
#5 (.125")	40		1/4	1/4		4.70	100
	40		3/8	3/8		4.75	100
	40		1/2	1/2		4.95	100
	40		5/8	5/8		5.15	100
	40		3/4	3/4		5.35	100
#6 (.138")	32	40	1/4	1/4	1/4	4.75	100
	32	40	3/8	3/8	3/8	4.80	100
	32	40	1/2	1/2	1/2	5.00	100
	32	40	5/8	5/8	5/8	5.20	100
	32	40	3/4	3/4	3/4	5.45	100
	32		7/8	7/8		5.75	100
	32		1	1		6.15	100
#8 (.164")	32		1/4	1/4		4.85	100
	32	36	3/8	3/8	3/8	4.90	100
	32	36	1/2	1/2	1/2	5.10	100
	32		5/8	5/8		5.35	100
	32	36	3/4	3/4	3/4	5.60	100
	32		7/8	7/8		5.85	100
	32		1	1		6.35	100
	32		1 1/4	1 1/4		7.10	100
	32		1 1/2	1 1/4		7.85	100
#10 (.190")	24	32	3/8	3/8	3/8	5.05	100
	24	32	1/2	1/2	1/2	5.30	100
	24	32	5/8	5/8	5/8	5.55	100
	24	32	3/4	3/4	3/4	5.80	100
	24	32	7/8	7/8	7/8	6.05	100
	24	32	1	1	1 1/4	6.55	100
	24	32	1 1/4	7/8	1 1/4	7.30	100
	24	32	1 1/2	7/8	1 1/4	8.05	100
	24	32	1 3/4	7/8	1 1/4	8.80	100
	24	32	2	1	1 1/4	9.55	100
1/4 (.250")	20	28	3/8	3/8	3/8	5.25	100
	20	28	1/2	1/2	1/2	5.50	100
	20	28	5/8	5/8	5/8	5.75	100
	20	28	3/4	3/4	3/4	6.00	100
	20	28	7/8	7/8	7/8	6.25	100
	20	28	1	1	1	6.75	100
	20	28	1 1/4	1	7/8	7.50	100
	20	28	1 1/2	1	7/8	8.25	100
	20	28	1 3/4	1	7/8	9.00	100
	20	28	2	1	7/8	9.75	100
	20	28	2 1/4	1 1/8	7/8	10.50	100
	20		2 1/2	1 1/4		11.25	100
	20		2 3/4	1 3/8		12.00	100
	20		3	1 1/2		13.50	100
5/16 (.3125")	18		3/8	3/8		6.25	100
	18	24	1/2	1/2	1/2	6.50	100
	18	24	5/8	5/8	5/8	6.75	100
	18	24	3/4	3/4	3/4	7.00	100
	18	24	7/8	7/8	7/8	7.25	100
	18	24	1	1	1	7.75	100
	18	24	1 1/4	1 1/4	1	8.50	100
	18	24	1 1/2	1 1/4	1	9.25	100
	18	24	1 3/4	1 1/4	1	10.00	100
	18	24	2	1 1/4	1	10.75	100
	18	24	2 1/4	1 1/4	1	11.50	100
	18	24	2 1/2	1 1/4	1	12.50	100
	18		2 3/4	1 3/8		13.50	100
	18		3	1 1/2		14.50	100
	18		3 1/4			16.00	100
	18		3 1/2			17.50	100
3/8 (.375")	16	24	1/2	1/2	1/2	7.40	100
	16	24	5/8	5/8	5/8	7.70	100
	16	24	3/4	3/4	3/4	8.00	100
	16	24	7/8	7/8	7/8	8.50	100
	16	24	1	1	1	9.00	100
	16	24	1 1/4	1 1/4		10.00	100
	16	24	1 1/2	1 1/4	1 1/4	11.00	100
	16	24	1 3/4	1 1/4	1 1/4	12.00	100
	16	24	2	1 1/4	1 1/4	13.00	100
	16	24	2 1/4	1 1/4	1 1/4	14.00	100
	16	24	2 1/2	1 1/4	1 1/4	15.00	50
	16		2 3/4	1 3/8		16.00	50
	16	24	3	1 1/2	1 1/2	17.50	50
	16		3 1/4	1 3/8		19.00	50
	16		3 1/2	1 3/4		20.50	50
	16		4	2		24.00	50
	16		4 1/2	2 1/4		28.00	50
	16		5	2 1/2		32.00	50
7/16 (.4375")	14		1/2	1/2		8.90	100
	14		5/8	5/8		9.20	100
	14		3/4	3/4		9.50	100
	14		7/8	7/8		10.00	100
	14	20	1	1	1	10.50	100
	14	20	1 1/4	1 1/4	1 1/4	11.50	100
	14	20	1 1/2	1 1/4	1 1/4	12.50	100
	14		1 3/4	1 3/8		13.50	100
	14	20	2	1 3/8	1 1/4	14.50	50
	14		2 1/4	1 3/8		15.50	50
	14		2 1/2	1 3/8		17.00	50

Diameter	Threads per inch NC	Threads per inch NF	Length	Thread Length NC	Thread Length NF	Price per 100	Quantity per box
7/16 (.4375")	14		2 3/4	1 1/8		18.50	50
	14		3	1 1/2		20.00	50
	14		3 1/4	1 1/2		21.50	50
	14		3 1/2	1 3/4		23.00	50
	14		4	2		27.00	50
1/2 (.500")	13		1/2	1/2		10.20	100
	13		5/8	5/8		10.60	100
	13		3/4	3/4		11.00	100
	13		7/8	7/8		11.75	100
	13		1	1	1	12.25	100
	13		1 1/4	1 1/4	1 1/4	13.50	100
	13		1 1/2	1 1/2	1 1/2	14.75	100
	13		1 3/4	1 1/2	1 1/2	16.00	50
	13		2	1 1/2	1 1/2	17.25	50
	13		2 1/4	1 1/2	1 1/2	18.50	50
	13		2 1/2	1 1/2	1 1/2	20.00	50
	13		2 3/4	1 1/2		21.50	50
	13		3	1 1/2	1 1/2	23.00	50
	13		3 1/4	1 1/2		24.50	50
	13		3 1/2	1 3/4		26.00	50
	13		4	2		29.00	50
	13		4 1/2	2 1/4		32.00	50
	13		5	2 1/2		35.00	50
	13		5 1/2	2 3/4		38.00	50
	13		6	3		41.00	50
	13		6 1/2	3 1/4		44.00	50
	13		7	3 1/2		50.00	50
	13		8	4		62.00	50
5/8 (.625")	11		1	1	1	18.00	50
	11		1 1/4	1 1/4	1 1/4	19.75	50
	11		1 1/2	1 1/2	1 1/2	21.50	50
	11		1 3/4	1 3/4	1 3/4	23.25	50
	11		2	2	1 3/4	25.00	50
	11		2 1/4	1 3/4		27.00	25
	11		2 1/2	1 3/4	1 3/4	29.00	25
	11		2 3/4	1 3/4		31.00	25
	11		3	1 3/4		33.00	25
	11		3 1/4	1 3/4		35.00	25
	11		3 1/2	1 3/4		37.00	25
	11		4	2		41.00	25
	11		4 1/2	2 1/4		45.00	25
	11		5	2 1/2		49.00	25
	11		5 1/2	2 3/4		53.00	25
	11		6	3		57.00	25
	11		6 1/2	3 1/4		62.00	25
	11		7	3 1/2		70.00	25
	11		8	4		85.00	25
3/4 (.750")	10		1 1/4	1 1/4		24.00	50
	10		1 1/2	1 1/2		26.00	25
	10		1 3/4	1 3/4		28.00	25
	10		2	2		30.00	25
	10		2 1/4	2 1/4		33.00	25
	10		2 1/2	2		36.00	25
	10		2 3/4	2		39.00	25
	10		3	2		42.00	25
	10		3 1/4	2		45.00	25
	10		3 1/2	2		48.00	25
	10		4	2		53.00	25
	10		4 1/2	2 1/2		58.00	25
	10		5	2 1/2		63.00	25
	10		5 1/2	2 3/4		68.00	25
	10		6	3		73.00	25
	10		6 1/2	3 1/4		79.00	25
	10		7	3 1/2		86.00	25
	10		8	4		102.00	25
7/8 (.875")	9		2	2		47.00	25
	9		2 1/4	2 1/4		50.00	25
	9		2 1/2	2 1/2		53.00	25
	9		2 3/4	2 1/4		56.00	25
	9		3	2 1/4		60.00	25
	9		3 1/4	2 1/4		64.00	25
	9		3 1/2	2 1/4		68.00	25
	9		4	2 1/4		74.00	25
	9		4 1/2	2 1/4		81.00	25
	9		5	2 1/2		88.00	25
	9		5 1/2	2 3/4		95.00	25
	9		6	3		102.00	25
	9		6 1/2	3 1/4		111.00	25
	9		7	3 1/2		120.00	25
	9		8	4		138.00	25
1 (1.000")	8		2	2		53.00	25
	8		2 1/4	2 1/4		56.00	25
	8		2 1/2	2 1/2		60.00	25
	8		2 3/4	2 1/2		65.00	25
	8		3	2 1/2		70.00	25
	8		3 1/4	2 1/2		75.00	25
	8		3 1/2	2 1/2		80.00	25
	8		4	2 1/2		88.00	25
	8		4 1/2	2 1/2		96.00	25
	8		5	2 1/2		105.00	25
	8		5 1/2	2 3/4		114.00	25
	8		6	3		123.00	25
	8		6 1/2	3 1/4		133.00	25
	8		7	3 1/2		143.00	25
	8		8	4		167.00	25

Prices subject to change without notice.

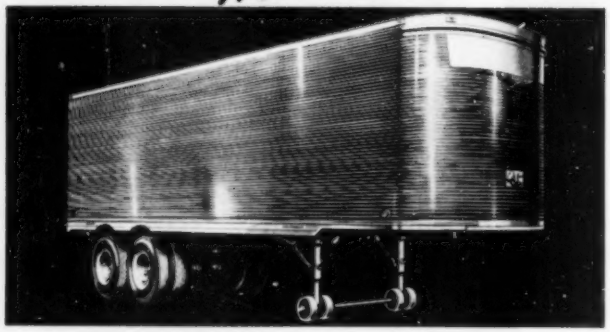
LIST PRICES SUBJECT TO DISCOUNT

Why order "specials"? UNBRAKO *standards* may do the job!

O & S BEARINGS
NON-METALLIC • SELF LUBRICATING

. . . . . are Typical of the Original Equipment that Makes

FRUEHAUF *GREAT from the Ground Up!*



To many the two O & S Bearings shown here will appear relatively unimportant in so huge a thing as a trailer. To Fruehauf engineers — these bearings, as every other part or piece of material, are tremendously important. That's why Fruehauf is "great from the ground up."

O & S bearings are produced by a company with 38 years of manufacturing skill and engineering experience. O & S non-metallic, self lubricating bearings are designed for a definite job . . . built to do that job — better — longer and more economically.

WRITE TODAY FOR BULLETIN 251
OR SEND PRINTS AND DETAILS

Our 38th Year Manufacturing Original Equipment

NeverOil SINCE 1913
O & S BEARING CO.
303 SOUTH LIVERNOIS • DETROIT 17, MICHIGAN

and a variety of colors can be produced. Since it contains no chemical plasticizer to leech out or harden, flexibility is retained.

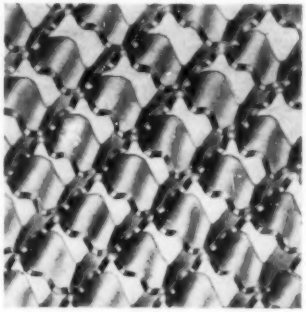
A sharp instrument will cut through the film but the break can be repaired easily by "touching up" with brush or spray. Prior to application metal should be grit or sand-blasted, and cement etched with hydrochloric acid, while wood and composition board need rough sanding to assure a good bond. United States Rubber Co.,

United States Rubber Co., Rockefeller Center, New York 20, N. Y.

Non-Skid "Firm-Grip" Grating Has More Traction

The non-slip quality of this grating renders it applicable for industrial use where excessive oil, grease, water, and icy conditions make walking and working hazardous, and where drainage and sanitation are desirable factors.

It is especially adaptable for plat-



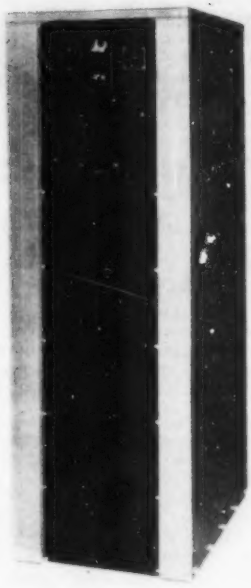
forms, stair treads, ramps, catwalks, running boards, skidmats, steps for trucks, trailers, submarine decks, ladder rungs, ships, railroad industry, machine treadles and engine rooms.

Bustin Iron Works, Inc., 100 E. 130th St., New York 35, N. Y.

Induction Voltage Regulators for 3 Phase Power

To complement their "Triplex" units, the manufacturers are offering a line of 3 phase, dry type, induction voltage regulators for regulating 3 phase power at low voltage. This line includes both self cooled and forced air cooled regulators in 10 percent and 20 percent ranges of regulation. Ratings range from 12 to 85 kva.

These units differ from the Triplex



assembly, which consists of 3 single phase regulators on a single base, in that it is a three phase winding on a single core. A steel, ventilated cabinet houses the electrical components and protects them from excessive dust collections.

General Electric Co., 1 River Rd., Schenectady, N. Y.

Hermetically Sealed Timer

This timer has been developed to meet the need in commercial and military equipment for a fixed time delay unit, positive in operation, requiring no warm-up and unaffected by variations in temperature and supply voltage and frequency. It is designed to provide a fixed time delay of any value within its range. This time interval is factory preset. It is initiated by a contact closure and operates, at the end of the timed interval, a single pole, double throw relay. The timing is accomplished by charging a condenser through a resistance from a regulated voltage source. This terminates with the conduction of a gas filled tube and results in the operation of a relay.

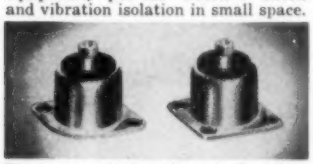
Power consumption is low ($\frac{1}{2}$ watt in standby; 4 watts operated), and the timer is hermetically sealed with time interval preset at factory. It is instantaneously recycling. However it may be furnished with the delay pro-

SHOCK and VIBRATION NEWS

BARRYMOUNTS FOR ASSURED CONTROL OF SHOCK AND VIBRATION

SMALL AIR-DAMPED BARRYMOUNTS *for Miniaturized Airborne Equipment*

New-series Barrymounts, designed to meet requirements for compact isolators usable with miniaturized equipment, provide effective shock and vibration isolation in small space.



These mountings utilize air damping to minimize shock of aircraft landing and taxiing and to limit excursion so there is no snubber contact, even at resonance.

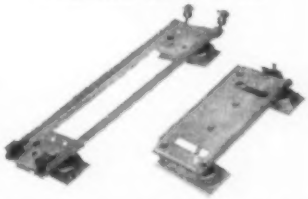
Upright and inverted types are available for two-hole or four-hole mounting. Unit mountings are one inch in diameter and 1-1/32 inches high under maximum rated load. Load ratings are 0.1 to 3.0 pounds per mount. The mountings weigh only 5/16 ounce each.

Bases using the inverted mountings raise the mounted equipment only 1/2 inch. Either upright or inverted unit mountings can be furnished on bases that conform to your specifications, load-ratings, and dimensions.

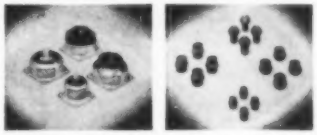
FREE CATALOGS

- **502** — Air-damped Barrymounts for aircraft service; also mounting bases and instrument mountings.
- **509** — ALL-METL Barrymounts and mounting bases for unusual airborne applications.
- **605-606** — Miniaturized air-damped Barrymounts for use with airborne equipment.

STANDARD MOUNTINGS ISOLATE VIBRATION *Available for Aircraft, Marine, Mobile, Instrument, and Industrial uses.*

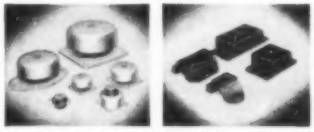


Standard bases built to meet government specifications can be furnished by Barry; special bases can be supplied in sizes and load ratings to fit customers' exact requirements, including miniaturized bases. See catalog 502 and data sheets 605 and 606.



Aircraft vibration isolators designed to meet Army, Navy, and CAA requirements are available in ¼-pound to 45-pound unit ratings; also miniature mounts to 0.1 lb. See catalogs 502 and 509 and bulletins 605-6.

Instrument mountings are furnished for electronic components, tiny, fractional-HP motors, record changers, dictating machines, and other lightweight apparatus. See catalogs 502 and 504.



Shock mountings for mobile, railroad, and shipboard service also give vibration isolation at frequencies above 2000 c.p.m.; useful for general sound isolation. See catalog 504.

Industrial mountings isolate vibration from fans, motor-generator sets, transformers, punch presses, and other heavy industrial equipment. Bulletin 607 tells how to cut maintenance costs with Barrymounts.

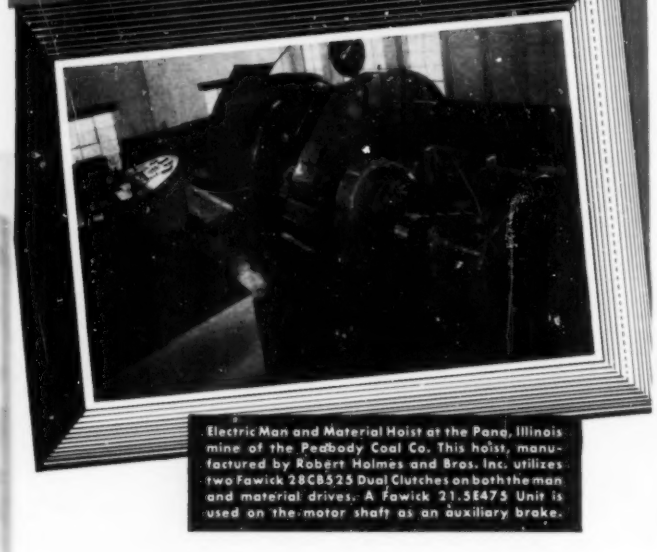
THE BARRY CORP.

730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN

New York · Rochester · Philadelphia · Washington · Cleveland · Dayton · Detroit
Chicago · Minneapolis · St. Louis · Seattle · Los Angeles · Dallas · Toronto

FAWICK CLUTCHES INSURE POSITIVE REMOTE CONTROL ON MINE HOIST INSTALLATION



Electric Man and Material Hoist at the Pana, Illinois mine of the Peabody Coal Co. This hoist, manufactured by Robert Holmes and Bros. Inc. utilizes two Fawick 28CB525 Dual Clutches on both the man and material drives. A Fawick 21.5E475 Unit is used on the motor shaft as an auxiliary brake.

Fawick Airflex Clutches play a very important part in the operation of this heavy-duty mine hoist, where the repeated starting and stopping throw heavy loads on the entire drive mechanism.

The two Fawick Dual Clutches installed on the low and high speed drives provide vital operating characteristics. They give instant response to remote control from the "hoistman's" station, permitting "shifting" of hoist speeds.

The cushioning action of the flexible Fawick Clutch operating tubes reduces load shocks to the gearing.

These same operating characteristics plus the rugged design and simplicity of Fawick Clutches and Brakes contribute greatly to long, top-efficiency operation in industrial applications. On this, as on many other installations, Fawick Clutches make good machines better.

FAWICK AIRFLEX CO., INC.
9919 CLINTON ROAD, CLEVELAND 11, OHIO

For specific information on all advantages of Fawick Clutch and Brake units, write to the Main Office, Cleveland, Ohio, for Bulletin 300.

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

portional to the time between operations for tube warmup applications.

The timer is said to be designed to withstand and operate under the conditions of vibration and shock, as well as temperature and humidity, normally specified for military equipment.

G. C. Wilson & Co., Chatham, N. J.

Thread Compound Resists Seizing

Seizure of pipe, bolt and stud threads and gasket faces is resisted by a metallic compound which combines the advantages of a lubricant and sealer. It is effective at temperatures from minus 350 deg F to plus 2900 deg F and higher. The metallic ele-

ments, which consist of over 70% powdered lead, are held in suspension in hydrocarbons. The materials, it is claimed, will not dry out, thus insuring ease of disassembly. No graphite is used. The compound conforms to government specifications and can be used for steam, gas, water, air, oil, ammonia and various chemical connections.

Armite Laboratories, 6662 Broad St., Los Angeles 1, Calif.

New Safety Valve

Safety for operators is offered by an air control solenoid valve that moves to a safe setting even if the air or electrical supply should be interrupted. Elimination of all springs and the use of a clapper type solenoid are the principal safety features.

The orifice is designed to provide maximum capacity. The major pistons and poppets are in one unit to assure simultaneous movement. Free and continuous operation is provided by floating the pilot operating lever on needle bearings. Manual operation is also provided.

The valve ordinarily operates with

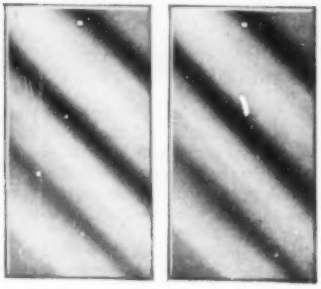
(Advertisement)

Clear Coatings for Zinc and Steel Stand 800 hours' Salt Spray

Increased use of zinc die castings and of zinc-plated steel to replace unavailable materials, combined with the tight supply of copper, nickel and chromium normally used for plating zinc, has focused attention on surface coatings comparable to plating in service performance. Unbiased laboratory tests show that at least two of the clear finishes in the company's line withstand the exceptionally long period of 800 hours' exposure to salt spray and to weatherometer tests.

Effectively protect zinc

These tests demonstrate that DULAC Clear Universal Lacquer #462 and CODUR Clear Synthetic Y743 provide completely satisfactory protection on zinc, zinc plated steel and steel. Even after the unusually severe tests to which these finishes were subjected, there was no indication whatever either of failure of the coating or of discoloration of the zinc.

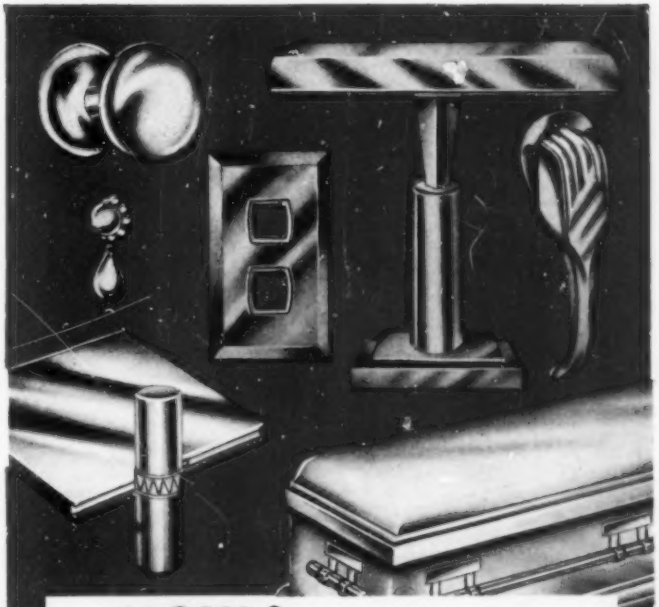


(Left) A zinc-plated steel panel newly coated with DULAC #462. (Right) A similar panel after 800 hours' exposure to salt spray, showing no evidence of attack on the finish.

Adaptability to Drying Schedules

While both finishes give the same performance, DULAC #462 is an air-drying coating, while CODUR Y743 is a baking type. This permits choice of the correct finish to fit into the drying schedules of a particular finishing room.

Technical Data Bulletin #110 on clear finishes is available from Maas & Waldstein Co., 430 Riverside Avenue, Newark, 4, N. J. On request, M & W Technical Service Engineers will discuss specific problems.



NOW! simulate copper, brass and bronze on products like these with

M&W PLATELUSTRE

● Don't let critical metals put a *needless* crimp in your production!

Take zinc or steel—apply a coating of one of the new PLATELUSTRE finishes. You wind up with products and parts that look so much like copper, brass and bronze that *the eye can scarcely tell the difference!*

Whether you have been using now unavailable copper and its alloys for *making* products or for *plating* products, you will find these new M & W finishes *equally* effective in keeping your plant running. There are types for air-drying and baking schedules — pick the one that best fits *your* production requirements.

Let an M & W Technical Service Engineer show you—*right in your own plant*—how easy these PLATELUSTRE coatings are to use, and what striking effects they produce. Or, if you prefer, write for free literature.

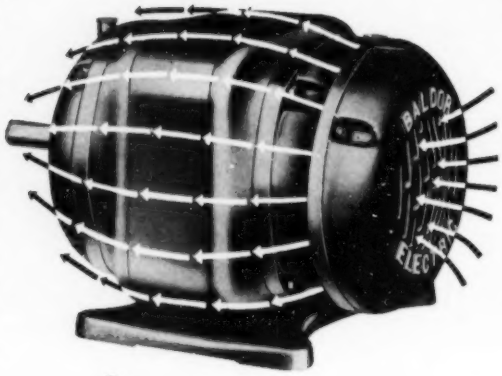
PIONEERS IN PROTECTION

75th ANNIVERSARY • MAAS & WALDSTEIN CO. 1876

MAAS & WALDSTEIN CO.

MID-WEST DIV. - 1650 CARROLL AVE., CHICAGO 12, ILLINOIS
PACIFIC COAST DIV. - SMITH-DAVIS CO., 10751 VENICE BLVD., LOS ANGELES 34, CAL.
MANUFACTURERS OF INDUSTRIAL FINISHES

Glass Insulated
BALL-BEARING MOTORS
conserve copper and other critical materials and have longer service life



BALDOR Glass-insulated Motors help in the war effort by conserving copper and other critical materials—*without sacrificing quality or performance.*

Glass-insulated motors provide *more horse-power in smaller frame sizes.*

They withstand high ambient temperatures and are not affected by moisture nor constant peak loads.

May we send you complete engineering data?

BALDOR ELECTRIC COMPANY
4353 DUNCAN AVE. • ST. LOUIS 10, MO.

Baldor
The Pioneer Manufacturer of
GLASS INSULATED MOTORS
SALES AND SERVICE IN OVER 300 TRADE CENTERS

line pressures of 40 to 125 psi but can be changed to work outside these limits. It is available in ¼ in. to 1¼ in. pipe sizes, straightway or 3-way, normally closed or normally open models.

Ross Operating Valve Co., 120 E. Golden Gate, Detroit 3, Mich.

Vacuum Chamber Tests Components

A vacuum test chamber complete with pump and direct reading altitude gage tests component parts at various altitudes or degrees of vacuum. A pressure regulating valve can maintain pressure equivalent to that at 60,000 ft altitude.

The drum head is of welded construction; its flanged circular door is heavy glass with a sealing ring and latches. A 1 in. utility port admits electrical leads etc. Inside dimensions are 19½ in. dia by 30 in. plus additional space in the drum head. The chamber comes complete with pump in one unit or as a table model with the pump unmounted.

O. S. Tyson and Co., Inc., 230 Park Ave., New York 17, N. Y.

Packaged Amplifiers For Automatic Control

This is a line of standard push-pull magnetic amplifiers, completely self-contained and ready for immediate use. All components are enclosed in a sealed metal can. Models for operation on 115 v, 400 cycles include units with power ratings of 5, 10, 15

GITS Unit* SEAL
Now STANDARDIZED

For . . .

Gear Reduction Units
Aircraft Reciprocating Engines
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If *you* have a shaft sealing problem, Gits experience in these and many other specific applications can prove of great and immediate value to you.

Write today for FREE illustrated Brochure, or send us your seal problem.

*Cartridge Seal . . . pressure balanced . . . requiring only 25% more space than lip-type seals.

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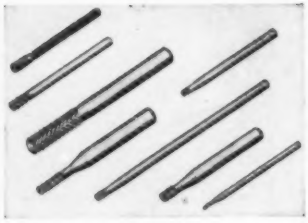
Gits Lubricating Devices,
The Standard For Industry For Over 40 Years

IT COSTS LESS

to have your precision metal parts made by

TORRINGTON



Special equipment and volume production enable us to save for you on a wide variety of precision parts made to order.

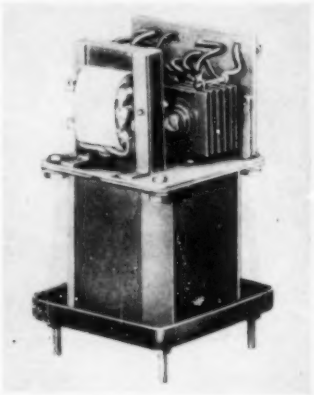
Typical are mandrels or spindles for mounted grinding wheels, abrasive points, felt wheels. Shank diameters to .500", close tolerances, centerless ground if desired. Chuck ends rounded, no burrs. Sharp, clear uniform knurls. Concentric tapers. Mandrels accurately hand-straightened.

We are also set up to make for you such parts as special rollers, studs, dowel pins, screw driver and ice pick blades, surgical and dental instruments, pen and pencil barrels, instrument shafts and pivots, special needles, etc.

Send your prints and specifications today for a prompt quotation.

THE TORRINGTON COMPANY
Specialty Department
554 Field Street • Torrington, Conn.

Makers of
TORRINGTON NEEDLE BEARINGS



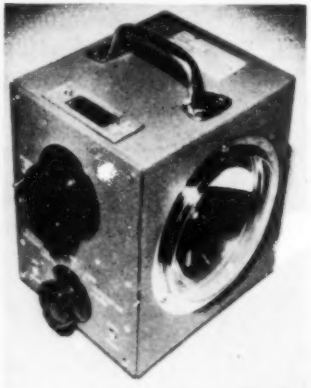
and 20 w; and those for 115 v, 60 cycles have outputs of 2, 5 and 10 watts. Input resistances of 1, 10, or 400 ohms can be supplied as well as output voltages of 220, 115, 67, and 26 volts.

Magnetic Amplifiers, Inc., 11-54 44th Dr., Long Island City 1, N. Y.

Strobotac Measures Speeds Up To 100,000 Rpm

The fundamental range of flashing speed of this stroboscopic tachometer is 600 to 14,400 per minute. Rpm can be read directly. Power supply is 105 to 125 volts, 50/60 cycles.

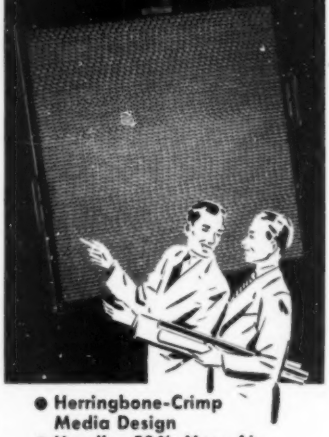
By using multiples of the flashing speed, the range of measurement can be extended to about 100,000 rpm. By multiple images, speeds below 600 rpm can be measured. Accuracy of



±1 percent of the dial reading of the Strobotac is obtainable.

Electronic Measurements Co., Red Bank, N. J.

You get measurably more for your money in **FAR-AIR** Filters!



- **Herringbone-Crimp Media Design**
- **Handles 50% More Air Per Unit**
- **Stronger Frames**
- **Reinforcing Rods**
- **More Media**
- **Holds More Dirt**
- **Easier to Clean**
- **Less Pressure Loss**

These and many more quality features make FAR-AIR Filters the choice of discriminating organizations. They are available in a wide range of types and sizes for dirt, lint, grease, entrained water, ink, paint and most other filtering applications. Sturdy construction and precision engineering gives them longer service life.

Every claim made for FAR-AIR Filters can be proved by you with a simple test. For complete information, write to Farr Company, 2615 Southwest Drive, Los Angeles 43, Calif.

Among the users of FAR-AIR Filters are:
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General Electric Company
Standard Oil Co. of Indiana
R.C.A. Victor Division
A. B. Dick Company
U. S. Armed Forces

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"Better by Farr"
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FARR COMPANY
Manufacturing Engineers
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EVERYONE who drives . . . and that means everyone from the average motorist to drivers of the biggest buses and trailer trucks . . . wants safe, sure stops and quick, smooth starts. What they want takes the finest brake lining, brake blocks, clutch facings, and engineered automatic transmission parts.

That's why vehicle manufacturers, as well as makers of many other kinds of equipment, rely on Raybestos-Manhattan, the world's leading supplier of friction materials. They know from experience that R/M STOP AND GO products meet every requirement . . . can always be counted on for greater safety and longer, more economical wear.

R/M friction materials are serving today in applications that vary from heavy-duty trucks to tiny precision parts for adding machines. This diversity provides a breadth of experience that can be most helpful to you.

Remember that when you call in your R/M representative, you enlist the full support of four great plants, four research departments, and four testing laboratories!

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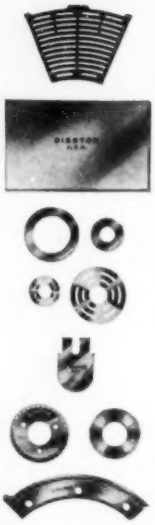

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CATALOGS and BULLETINS

(29) INDICATING PYROMETER CONTROLLERS — Wheel-co Instruments Co. Bulletin, 2 pp. Presents the design, measuring circuit and control system features of the Model 292 Capacitrol—a self contained indicating deflection type instrument for measurement and automatic control of temperatures on any type heating equipment.

(30) ELECTRONIC AIR CLEANER—Westinghouse Electric Corp. Booklet (SA-6691), 8 pp. The operation, construction, and application of electronic air cleaning units are discussed. Units for factories, offices and homes are covered.

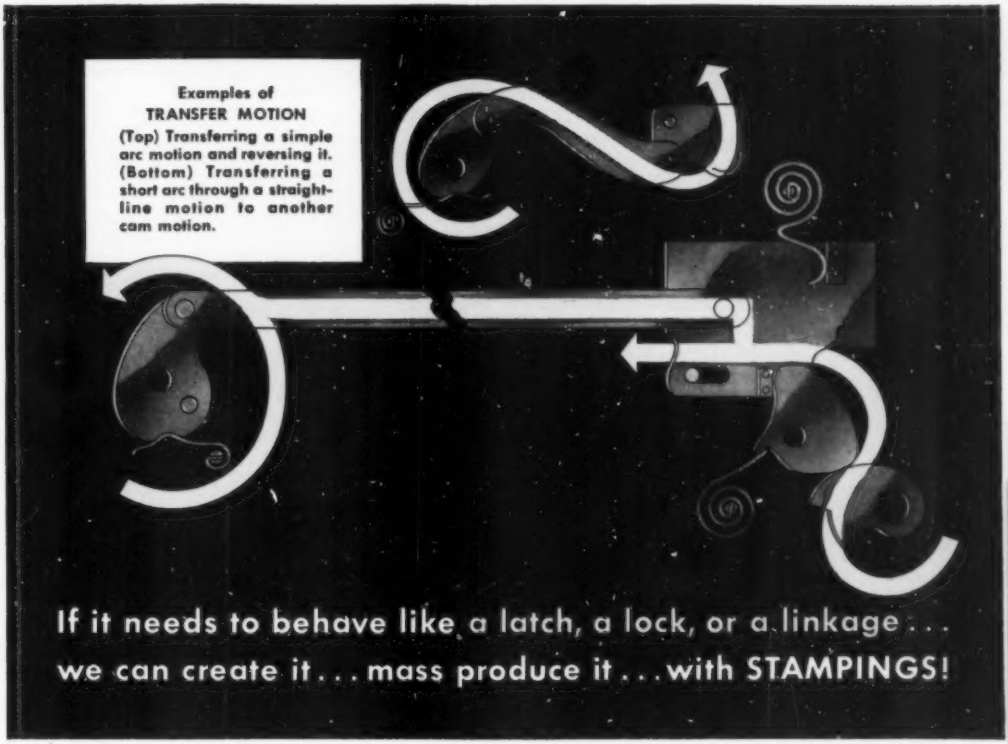
(31) HIGH TEMPERATURE TUBING—The Babcock and Wilcox Tube Co. Bulletin 12F. Contains condensed technical information including analyses, physical and mechanical properties, creep strength, tensile strength and oxidation resistance of fourteen tubing steels.

(32) PACKINGS AND GASKETS—Packing Div., Raybestos-Manhattan, Inc. Catalog, 100 pp. Complete descriptions and illustrations of various packings and gaskets including Teflon products, are presented in this booklet. Engineering data include charts showing recommendations for packing various types of equipment against various services; common causes for packing failure; installation procedures; advantages of lantern glands; conversion table; steam table and other pertinent facts.

(33) TENSION LINKAGES—Baldwin-Duckworth Div., Chain Belt Co. Bulletin No. 51-10, 16 pp. Prepared for machine designers, this bulletin contains informative engineering data on tension linkages with examples of typical applications.

(34) THERMO-REGULATORS AND THERMOSTATS — H-B Instrument Co. Catalog No. 18, 12 pp. Illustrated with photographs and cut away drawings, this booklet provides a useful aid to engineers and technicians interested in precise and reliable temperature control and regulation.

(35) POWER OPERATED PLUG VALVES—Rockwell Mfg. Co. Bulletin V-214, 40 pp. Offers a complete compilation of technical data covering the


Examples of
TRANSFER MOTION
(Top) Transferring a simple arc motion and reversing it. (Bottom) Transferring a short arc through a straight-line motion to another cam motion.
If it needs to behave like a latch, a lock, or a linkage . . .
we can create it . . . mass produce it . . . with STAMPINGS!

Keep your product in mind as you check through these types of "Motions" made by Standard. They include devices to: spring open or shut a lid . . . start or stop a machine . . . lock or latch a door . . . raise or lower a panel . . . initiate or check a movement . . . position or control a force.

In this list may be a "Motion" which is required in *your* product. If so, remember that Standard Products engineers are full-time specialists in designing sure-acting motions that *exactly* fit the needs of the job to be done. Furthermore, by employing modern mass-production and assembly techniques, we can make motion-devices with *stampings* . . . to keep the cost unusually low.

For further information about our facilities, write today for a copy of our new booklet, "We Make Motions".

THE REID DIVISION OF *The Standard Products Co.*

THE MARK OF A SUPERIOR PRODUCT

DEPT. D, GENERAL OFFICES: 2130 WEST 110 STREET • CLEVELAND 2, OHIO

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Preferred power on orchard sprayers and other orchard equipment — the world's most widely used single-cylinder gasoline engines on machines and tools for industry, construction, railroads, oil fields, etc., and on appliances and equipment for farm and home.

THIS TRADE-MARK is your guide to all that is best in 4-cycle, single-cylinder, air-cooled gasoline engine performance.
Briggs & Stratton Corporation,
Milwaukee 1, Wis., U.S.A.

In the automotive field Briggs & Stratton is the recognized leader and world's largest producer of locks, keys and related equipment.

use of pneumatic, hydraulic, and electric operators for lubricated plug valves. Included are typical piping diagrams, arrangements for both side and top mounted motor controls, closing speeds, wiring data and photos of actual installations.

(36) SPECIAL CLEANING EQUIPMENT—American Wheelabrator and Equipment Corp. Catalog No. 724, 27 pp. Illustrates and explains the uses and advantages of specially designed cleaning and finishing machines and cabinets for products requiring special handling or high production rates.

(37) METAL MOLD CENTRIFUGAL CASTING—U. S. Pipe and Foundry Co. Booklet, 12 pp. Describes the production of cylindrical shapes in various alloys by means of a process that is said to provide refined grain structure and freedom from voids and impurities. Dual metal casting—the joining of two dissimilar metals by centrifugal force—is also explained.

(38) COMPRESSORS AND CONDENSING UNITS — Westinghouse Sturtevant Div. Bulletin 101-110. Illustrates and describes in detail the features of the 2, 3, 5 and 7½ hp hermetically sealed refrigeration compressors and condensing units. Specification data is included.

(39) ROTARY WORK FEED TABLE—The Bellows Co. Bulletin T-80, 12 pp. Included in this bulletin describing the firm's rotary feed table are installation photographs, dimensional drawings, specifications, wiring diagrams and electrical hook-ups with other pneumatic devices.

(40) ELECTRONIC PARTS—A. W. Franklin Mfg. Corp. Catalog, 20 pp. A drawing, specifications and dimensions are given for each of a large group of sockets, anode connectors, terminal and speaker strips, plugs and jacks, stamped circuits, and other parts for television, radio and electronic assemblies.

(41) CLOCK MOVEMENTS AND SWITCH TIMERS — The Sessions Clock Co. Bulletin No. CM-11, 12 pp. Dimensional drawings and complete specifications are included in this engineering and buying guide for specialty clock manufacturers, design engineers and all users of clock timing movements.

(42) ALUMINUM STRUCTURAL DESIGN—Reynolds Metals Co. A 130 page ring binder 6 x 9 data book to enable the engineer familiar with mechanics of materials to design original structure of aluminum, or to convert an existing structural design for some other material to aluminum. Included are the mechanical properties of aluminum alloys, working stresses,

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FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

KAYDON precision needle rollers are factors in tractors, too...

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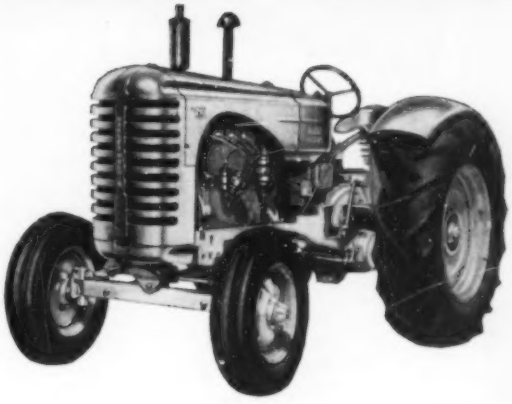
"Make it a Massey-Harris"

Now Massey-Harris engineers have adopted KAYDON Precision Needle Rollers for the transmission gears of their Model 55 Tractors. Here, as in many other automotive transmissions, universal joints, clutches, steering gears and various precision assemblies in all types of machinery . . . these dependable, economical precision needle rollers are "making good."

Billions of them are being made in standard sizes, 1/16" to 5/16" diameters (tolerance .0002" on diameter), flat or rounded ends. You get the benefit of low cost for highest performance-proved quality, in small or large quantities.

Used between hardened shafts and hardened bores of housings or gears, they eliminate need for bearing races and they provide the most compact high-capacity anti-friction bearing possible. They require no more space than so-called plain or "solid bearings." • Tell us what sizes and quantities you might use. It pays to "contact KAYDON of Muskegon."



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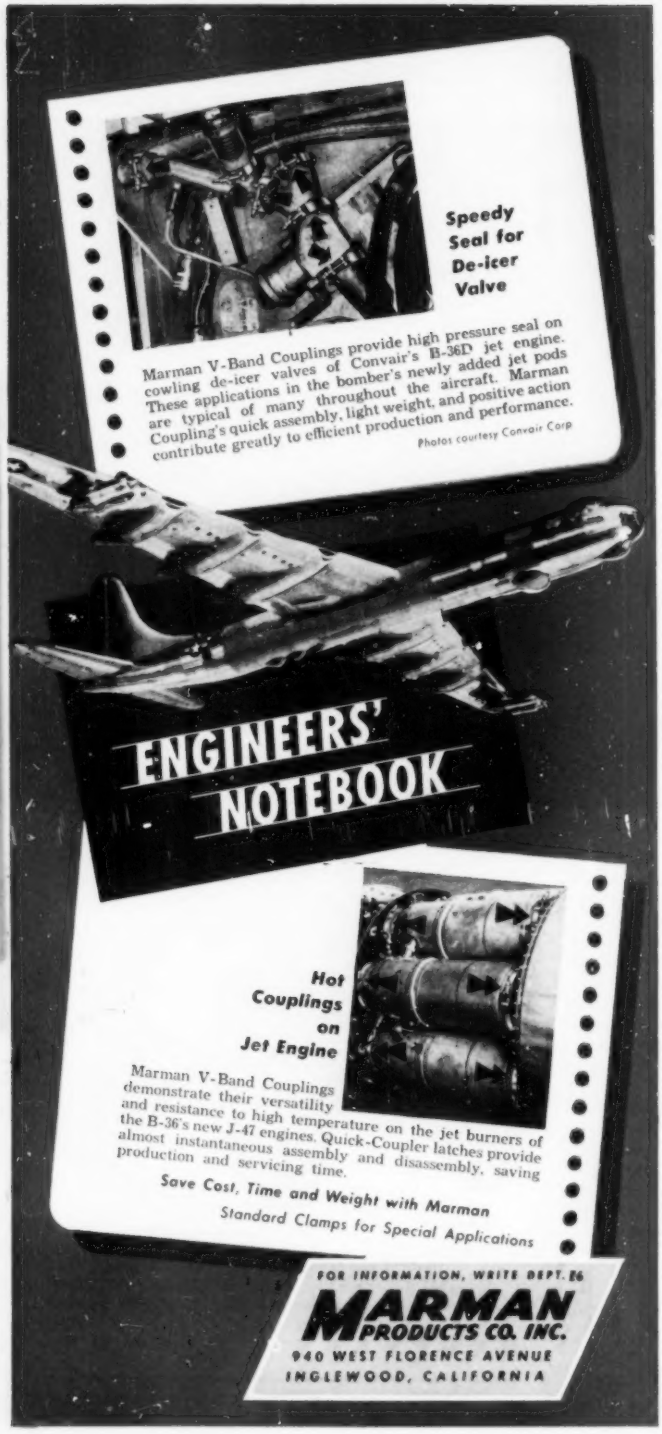
MUSKEGON • MICHIGAN

PRECISION BALL AND ROLLER BEARINGS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Marman V-Band Couplings provide high pressure seal on cowling de-icer valves of Convair's B-36D jet engine. These applications in the bomber's newly added jet pods are typical of many throughout the aircraft. Marman Coupling's quick assembly, light weight, and positive action contribute greatly to efficient production and performance.
Photos courtesy Convair Corp
ENGINEERS' NOTEBOOK
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New Catalogs.....continued

factors of safety and design formulas covering tension, compression, bending, and shear stresses, and formulas for cylinders, deflection and vibration. Thirty-eight tables covering mechanical properties of different materials, properties of aluminum in various forms, design formulas and properties of sections are included.

(43) OIL PURIFICATION—Honan-Crane Corp. Booklet, 16 pp. Information on oil purification for hydraulic equipment, metal working machines, gas and diesel engines, turbines and transformers is given in this booklet entitled "The Facts About Clean Oil". Illustrated applications of oil purification equipment to a variety of operations are presented.

(44) ELECTRIC HEATING ELEMENTS—Trent, Inc. Bulletin 74-TA, 24 pp. Describes full line of strip, immersion, cartridge, vane, space and other heaters, lead and Babbit melting pots, thermostats and switches. Also contains tables of specific heats and conversions, and a treatise on heating formulae.

(45) SPEED REDUCERS—D. O. James Gear Mfg. Co. Catalog No. 45-C, 8 pp. Specifications and Rating Tables are given for Type S worm gear speed reducers. Flexible couplings for use with these reducers are also listed.

(46) FREQUENCY CONTROLS—Electric Machinery Mfg. Co. Bulletin, 8 pp. Illustrates and describes the standard types of Polarized Field Frequency Synchronous Motor Controls for full voltage, reduced voltage and part-winding starting. Included in this booklet are ratings, weights, dimension drawings, wiring diagrams, and specifications for each type of control covered.

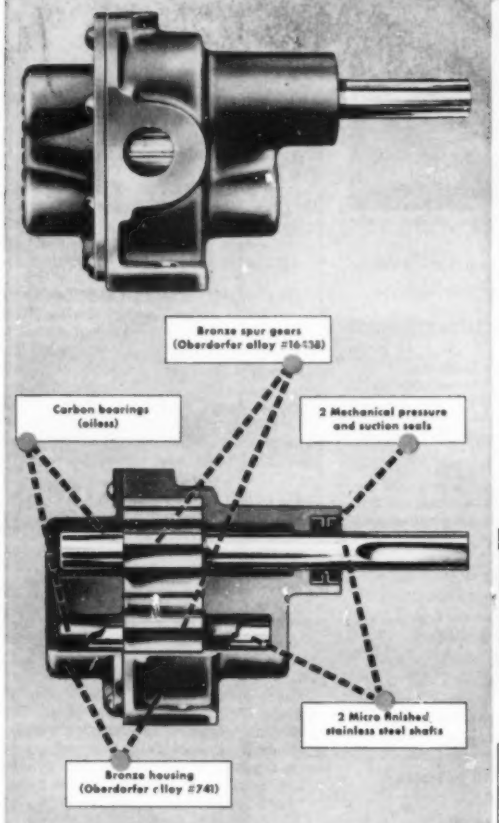
(47) LIQUID LEVEL CONTROLS—Charles F. Warrick Co. Catalog FA, 32 pp. Describes by illustrations and wiring diagrams the complete line of electrode type floatless liquid level controls. Electrode fittings and electrodes are also included.

(48) FLOATING DISK CLUTCHES—Carlyle Johnson Machine Co. Case history book. Shows original equipment installations of floating disk chambers. Illustrations and complete information are included on the firm's clutch and overload release clutch, especially designed for protection or high speed machinery such as packaging, labelling and wrapping machines.

(49) INDUCTION MOTORS—Westinghouse Electric Corp. Booklet (B-4739), 28 pp. Present a summary of the types and features of the two basic kinds of induction motors, type CSF squirrel cage motors for constant

Since the six OBERDORFER INTERNATIONAL pumps described below are new, with no prior history of use, Washington expects a DEFENSE ORDER or equivalent for their purchase. Free samples are available to O.E.M. accounts.

5 Major Points of Superiority in the New Series 1*...


Bronze spur gears (Oberdorfer alloy #16438)
Carbon bearings (oilless)
2 Mechanical pressure and suction seals
2 Micro finished stainless steel shafts
Bronze housing (Oberdorfer alloy #741)

OBERDORFER INTERNATIONAL BRONZE ROTARY GEAR PUMPS

These precision built pumps have been specifically designed for long and economical industrial service, and to reduce liquid transfer costs in the vast variety of applications where they are suitable. Their five major points of superiority incorporate all the engineering and production knowledge amassed in building literally millions of bronze pumps over a period of more than 50 years. These new Series 1 OBERDORFER INTERNATIONAL pumps will prove their worth in intensive, on-the-job tests against any competitive pumps on the market today.

CAPACITY TABLES

Gallons of Water Per Hour for Series 1 OBERDORFER INTERNATIONAL PUMPS
Outlet Pressure—P.S.I. (Pounds per square inch)

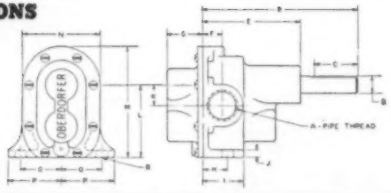
1725 RPM (Standard Electric Motor Speed)						
Pump Size	5 lbs.	20 lbs.	40 lbs.	60 lbs.	80 lbs.	100 lbs.
No. 1½	126	115	105	98	93	90
No. 2	245	225	215	205	195	190
No. 3	445	425	405	390	380	370
No. 4	640	610	580	550	530	510
No. 7	1185	1160	1140	1120	1100	1085
No. 9	1400	1375	1350	1325	1300	1280

PRICE LIST

Oberdorfer International Series 1
IMPORTANT: Order by Part Number

1½	2	3	4	7	9
Part No. 1000	Part No. 2000	Part No. 3000	Part No. 4000	Part No. 7000	Part No. 9000
$14.25	$15.75	$20.00	$22.25	$28.50	29.75

DIMENSIONS



Pump No.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
1½	½	½	1	3¹⁵⁄₁₆	2¾	⅝	1⅛	¼	1¼	⅜	¹⁵⁄₃₂	1⅛	2⅛	1¹⁵⁄₁₆	⅞	1½	⅜
2	⅝	½	1	3¹⁵⁄₁₆	2¾	¹⁵⁄₃₂	1⅛	¼	1⅜	½	⁷⁄₁₆	2⁵⁄₁₆	3⅛	2⅛	1⅛	1⅛	⅜
3	½	⅝	1½	4¹⁵⁄₁₆	3	¹⁵⁄₃₂	1⅛	½	1¼	½	⅝	2⅛	4	2½	1⅛	1⅛	⁹⁄₃₂
4	½	⅝	1½	5⅛	3⅛	⁹⁄₁₆	1½	⅝	1⅝	½	⅝	2⅛	4	2½	1⅛	1⅛	⁹⁄₃₂
7	¾	⅞	1½	5⅛	3⅛	⅝	1½	⅞	1⅞	⅝	1	3⅛	5⅛	3½	1⅛	2⅛	⁹⁄₃₂
9	1	⅞	1½	5⅛	3⅛	⅝	1½	⅞	1¹⁵⁄₁₆	⅝	1	3⅛	5⅛	3½	1⅛	2⅛	⁹⁄₃₂

FACTS ABOUT OBERDORFER

1. The third largest non-ferrous foundry in the U. S.
2. Over a half century of bronze pump manufacturing experience
3. Long-established world-wide pump distribution
4. Millions of pumps in service
5. Capitalization over one million dollars
6. 1951 capacity for 250,000 Series 1 OBERDORFER INTERNATIONAL pumps

* First of five new series

Write Dept. PE 516

INDUSTRIAL PUMP DIVISION
Oberdorfer Foundries, Inc.
Syracuse, N. Y.

LAMINUM looks like solid metal, but it's actually made up of .002 or .003 inch layers of first quality shim stock, metallically bonded together. Peels easily with a penknife.

LAMINUM, the metal that peels, comes in a wide range of thicknesses and laminations. Here is the basic information on this versatile, money-saving material.

STANDARD STOCK 8" x 48" SHEETS
BRASS AND STEEL

Gauge	.002 inch laminations	.003 inch laminations
.006	x	
.008	x	
.010	x	x
.016	x	x
.020	x	x
.032	x	x
.048	x	x
.062	x†	x†
.094††	x†	x†
.126††	x†	x†

†Also available as half laminated brass and half solid brass.
††Available in brass only.

PROPERTIES & SPECIFICATIONS

BRASS – Raw material is a commercial half hard high brass conforming to Federal Spec. QQ-B-611a, Comp C, half hard (5/27/44). The *laminated* brass conforms to Navy Aeronautical Spec. S-122, Aeronautical Material Spec. AMS-4508, Navy Ordnance Spec. 47B6.

STEEL – The raw steel used in LAMINUM conforms to Federal Spec. QQ-S-636, Condition 2, as well as SAE-1010. There are no government specifications on the finished steel LAMINUM.

Normally all LAMINUM stampings are made by us to our customers' specifications. However, for repair and maintenance work, some of our standard stock is available from your industrial distributor.

SHIM SIZE IS VIRTUALLY UNLIMITED

We've made some shims as large as 102 inches across—and others as small as your fingernail. With special joints developed over the years, we can make any size LAMINUM shim you want.

Other than standard thicknesses and lamination arrangements can be supplied upon special order.

BABBITTED SHIMS PREVENT OIL PRESSURE LOSS

Shims for use in split bearings can be fitted with babbitt lugs to prevent oil pressure loss without shaft scoring.

LET OUR ENGINEERS HELP YOU . . . We've been designing shims for 37 years. Why not throw that problem of yours at us? There's no obligation, of course.

SEND TODAY
FOR OUR ENGINEERING DATA FILE with all the quick facts on LAMINUM plus a free sample for your inspection.

*LAMINUM is used primarily for shims. But these facts may spark other thoughts that we'd be happy to help you develop.

LAMINATED SHIM COMPANY, INC.
1406 UNION STREET GLENBROOK, CONN.

CUSTOM SHIMS

STAMPINGS SHIM STOCK AN·COR·LOX NUTS

speed drive, and type CWF wound-rotor motors for adjustable speed drive. Applications for a number of industries are illustrated.

(50) HIGH SPEED CAMERA—Wollensak Optical Co. Bulletin, 12 pp. Describes the Fastax high-speed motion picture camera, its accessories and it industrial applications.

(51) CAST MONEL—The Cooper Alloy Foundry Co. Bulletin, 8 pp. Contains valuable information concerning the production of cast Monel, its physical and mechanical properties, corrosion resistance, machinability and weldability.

(52) SOLDERLESS TERMINAL LUGS—Krueger & Hudepohl. Bulletin 8-DF. Illustrates and lists sizes and prices of solderless terminal folding double cupped washer lugs.

(53) ELECTRONIC COMPONENTS—Stackpole Carbon Co. Catalog RC 8, 42 pp. Complete mechanical and electrical specifications are presented for standard fixed and variable resistors, line and slide switches, iron cores and choke forms. New additions include several single, dual shaft and special purpose volume controls, 3 ampere slide switches and non-metallic cores.

(54) ROLLER CHAINS AND SPROCKETS—Whitney Chain Co. Catalog RS-50. Provides complete specifications and engineering reference tables on American standard roller chains, sprockets and attachments. Dimensional data, strengths and weights on allied products, such block chain, cable chain and flexible couplings are also supplied.

(55) CIRCUIT BREAKERS—Heinemann Electric Co. Catalog, 12 pp. This catalog supplies information on the complete line of fully magnetic, non-thermal circuit breakers for general use, auxiliary circuit protection, panelboard applications and aircraft.

(56) RADIO AND ELECTRONICS PARTS—Sun Radio & Electronics Co., Inc. Catalog, 130 pp. Specifically prepared for industrial purchasing agents, research labs, schools and service dealers, this catalog gives technical information and illustrations on all radio, television and electronic items listed.

(57) CARBIDE TOOLS—The Atrax Co. Catalog, 22 pp. Describes and illustrates full line of carbide tools—end mills, reamers, burs, boring bits, grinding tools and drills.

(58) HYDRAULIC UNITS—Vickers, Inc. Catalog M-5100, 16 pp. Present specifications, charts and design details for oil hydraulic power packs, balanced vane pumps, multiple unit valves, steering booster and motors.

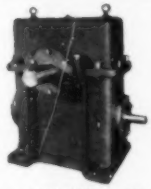
D.O.James

ESTABLISHED 1888

Available in either Horizontal or Vertical Drive

GEARED DRIVES MEET GROWING DEMANDS FOR POWER-SAVING EQUIPMENT IN INDUSTRY

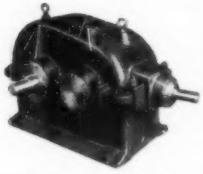
Continuous-tooth Herringbone
Single, Double, Triple Reduction



Type "H" Worm Gear

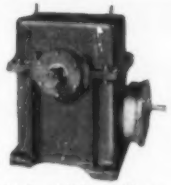
Straight Line Gear Reducer

Motorized Reducers

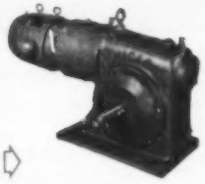


Spiral Bevel Herringbone

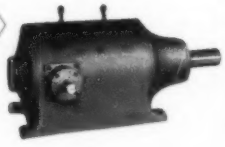
Double Worm Gear



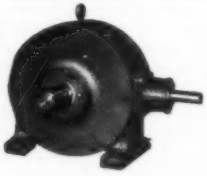
Helical Worm Gear



Motorized Worm Gear



Right Angle Gear Reducer



Spiral Bevel Gear

D.O.James Gear Manufacturing Co. is constantly developing and continuing to improve its variety of gear speed reducers—enabling engineers and designers of power-saving equipment to meet and cope with space limitations, horsepower requirements, ratios, location of driven or driving shafts and the type of drive that the many and varied installations require. Catalogs are available containing complete informative engineering data that will assist in the selection of the type of reducer for the specific job to be done.

D.O.JAMES GEAR MANUFACTURING CO.

Since 1888—Makers of Cut Gears, Gear Reducers and Flexible Couplings

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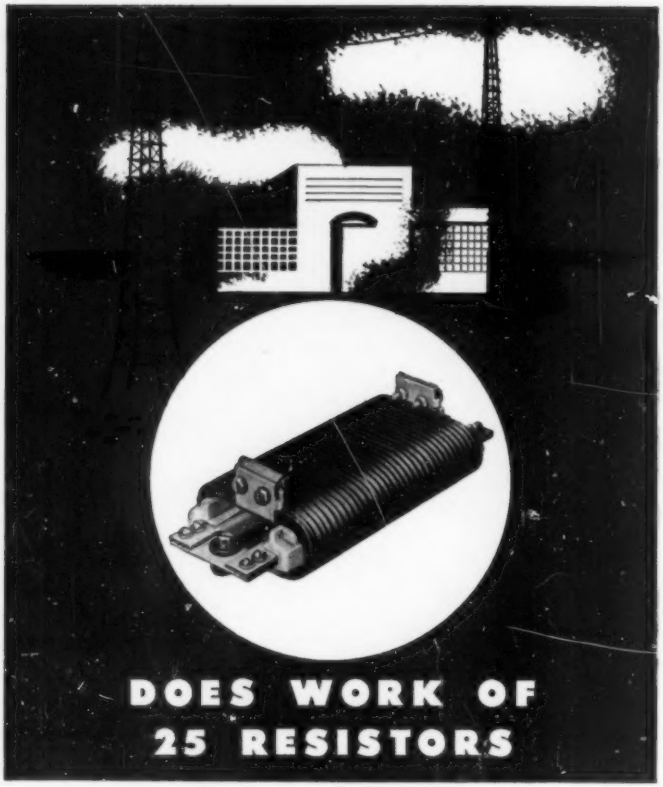


**saves work—and cost—
of hooking them up**

It used to take 25 conventional resistors, 11¾ x 1⅛ in., spaced on 2½ in. centers, to keep the power company happy.

Ward Leonard worked out the problem with a *single* Edgeohm resistor, 19 in. long—saving all that space, weight, mounting and wiring.

Here's the application: a 40-kw radio transmitter, operating from a 50 kva transformer, made by a large transmitter manufacturer. Problem: limiting inrush current to avoid a severe voltage drop (objected to by the power company) and a strain on the line contactor.

This single Edgeohm unit is rated for continuous duty at 2200 watts, and when used for a 15-second interval, will dissipate 6400 watts!

Another example of Ward Leonard "Result Engineering", providing the desired result at a saving! WARD LEONARD ELECTRIC CO., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

**WARD LEONARD
ELECTRIC COMPANY**

Result-Engineered Controls Since 1892

RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

Sans, Souci

Coincidences frequently occur. I had just gotten through the Souci of writing the editorial for this issue when I received a letter from my good friend H. A. Toulmin, Jr., a patent attorney of Dayton, Ohio. He is well known to most readers of PRODUCT ENGINEERING as he has been a frequent contributor. The Colonel, in his letter, mentioned a company which has profited immensely by stimulating the development of patentable inventions by their engineering and research departments. As the Colonel pointed out, this policy of selling licenses under the patents obtained was a means not only of increasing income but also of creating good will and public understanding. In other words, the company gets the benefit of his engineering research work by making it profitable to the company through the licensing of competitors and presumably the company will pay attractive salaries to its engineers to stimulate inventions. And as the Colonel put it, "I do not need to point out to you that the adoption of the correct policies (with reference to the stimulation of inventions, procuring patents and licensing them) has a great deal to do with the standing of engineering and the regard for it which managements will have in further expansion of engineering matters."

This reminds me of a little concern in Cleveland, Ohio which has only one business and that is inventing new products. It is a small organization. When a project is started, each and every employee is promised a certain percentage of the royalties that might be received from the invention if it is successful. This company already has a number of excellent inventions to its credit and the employees are happy and prosperous.

More and more companies are establishing incentives and rewards for new inventions developed by their engineers on company time. Such systems if properly installed and operated can be of tremendous benefit both to the company and the employee. Landers, Frary and Clark of New Britain, Connecticut have had such an incentive system for many years as described in the September 1945 issue of PRODUCT ENGINEERING.

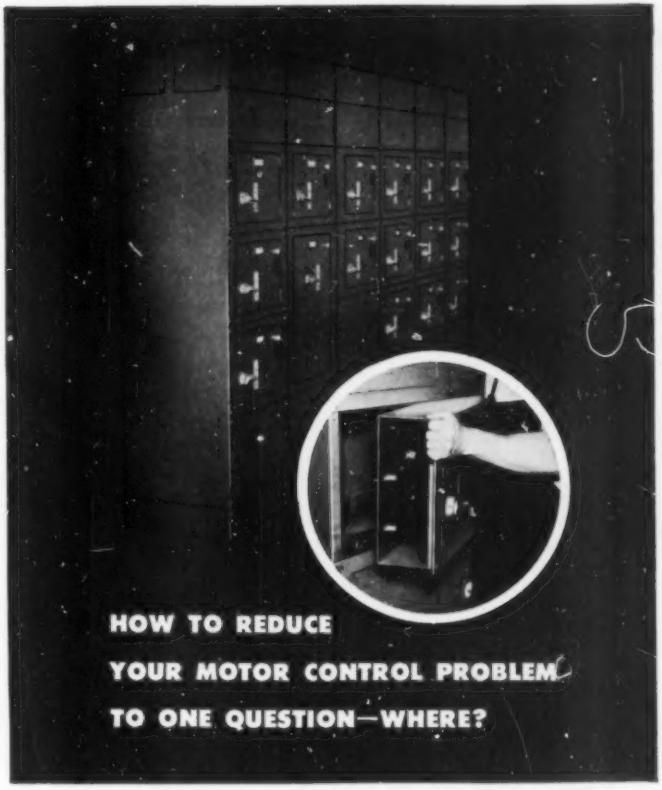
Just recently I attended a very significant meeting and heard a very significant remark. It only takes a sentence to give this remark, so I will pass it along. "The man who does not

read has no advantage over the man who cannot read." The more we think about that, the more significant the remark becomes. And it is not only a matter of just reading, but also understanding what you read.

It seems queer that so many engineers again and again will read an established fact and then ignore it completely when they are trying to figure out something. Only last week I was talking to my good friend, "Don" Vancil of the Cincinnati Milling Machine Company when he brought up a point of this kind. In the design of a huge press, it was essential that the tensile strains be held to a minimum. Now as every engineer knows, the total strain in inches will be the tensile stress divided by the modulus of elasticity and multiplied by the inches of length. In the particular problem under consideration, some person insisted that the tension members be made of alloy steel rather than the carbon steel which the engineering department had specified. It was extremely difficult to convince this person that there was absolutely no point in using alloy steel for such an application because low or medium alloy steel has a modulus of elasticity practically the same as that of carbon steel. And of course, if we were to take advantage of the higher yield point of the alloy steel and design the columns with smaller cross sections, but higher tensile stresses, the elongations would have to be proportionally higher. In other words, there was absolutely no sense in using anything other than carbon steel and a low working stress in order to keep the total strains to a minimum.

Perhaps such situations can be explained by the fact that in college the students are taught allowable stresses rather than allowable strains. In the conventional courses on machine design, there is too little taught concerning strains. As I remember it, the allowable twist in a shaft is about the only deflection problem that is presented with any degree of completeness. And yet here again we have an all too common mistake in the design of shafting.

My old professor, the late P. B. DeSchweinitz, many years ago designed one of the rolling mills at Bethlehem Steel. My numbers may not be exact, but as I remember it he had an 8 in. dia or 9 in. dia solid drive shaft between the reciprocating engine and the roll stand. Of course the engine reversed with extreme rapidity. After about twenty years of service, the shaft broke. A bright young engineer in the plant engineer-



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ing department of the company got the idea that if he designed a hollow shaft it would be much stronger, weight for weight, than the solid shaft that was used. So he designed the hollow shaft to operate at a working stress of about one-half of that of the solid shaft. At least that is the way he figured it. The shaft snapped the first time the mill reversed.

The big boss remembered who had designed the original mill and he called on old "Pop" DeSchweinitz to give some advice. It did seem strange that this hollow shaft with a section modulus twice that of the solid shaft had snapped. While Pop was standing there looking at the broken hollow shaft, someone suggested making this shaft of alloy steel and heat treating it. Pop's answer was, "You can do that but it would not change the modulus of elasticity". The half a dozen engineers standing around looked at Pop and from the expression in their eyes you could see that they began to think that Pop was getting a little queer in his old age. And old Pop had to go to quite some length to explain that the rigidity of the hollow shaft as compared to the springness of the solid shaft was such that the hollow shaft could not absorb the energy when the rotation was reversed without extremely high stress. The hollow shaft "had no wind-up". In other words, the stress developed during the reversals were roughly proportionately to the stiffness of the shaft. Needless to say, they put back a drive shaft identical to the original solid one.

It seems that some of the simplest facts in life are the least understood. Right along the same line as this discussion about modulus of elasticity we have the often repeated mistake of the engineering department in not dimensioning the drawings so that the production department doesn't have to do too much thinking. Too often the engineers leave it up to the production men to figure out things that the engineering department should tell them. And one of the most common mistakes is in the dimensioning of a series of holes lying in a straight line and which must match with holes drilled in another member. Instead of giving the distance from a gage point to each of the holes, the draftsman usually gives the dimensions from hole to hole. Of course in the shop this simply means that the errors in the spacings of the holes accumulate.

One of the most humorous situations of this kind was in the dimen-

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Insulation is *molded* for permanent dimensional accuracy . . . *color coded* for easy identification . . . *translucent* for visual inspection of assembly.

SIMPLE, SURE INSTALLATION

A single operation with Shure Stake Tools* *simultaneously* stakes terminal to wire with terrific pressure, and grips the insulation permanently in place. The terminal is on the wire to stay; the insulation is on the terminal to stay!

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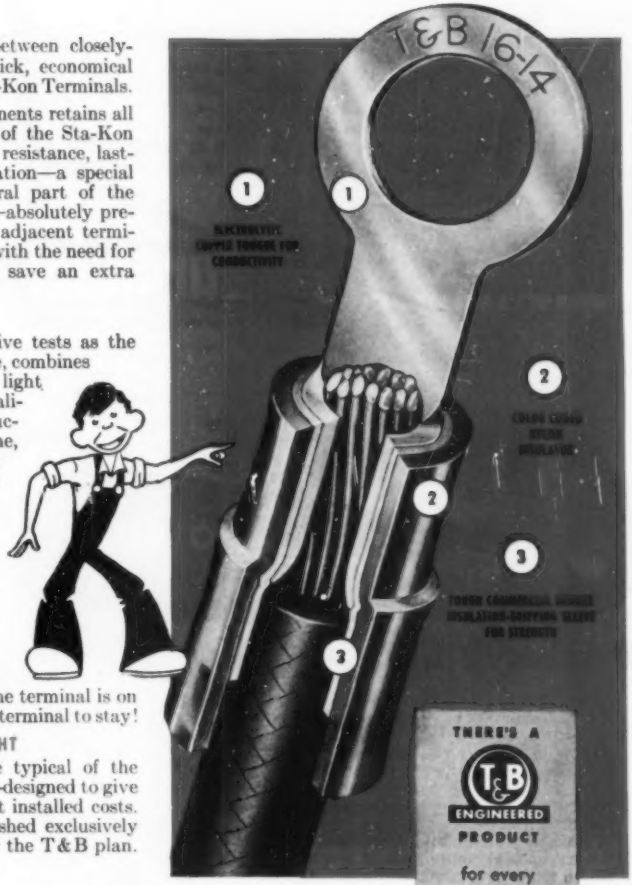

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SHURE-STAKE HAND TOOLS exert more than 2,000 pounds staking pressure (compared with 800 pounds for ordinary tools.) Once pressure has been applied, jaws cannot be opened until dies have closed all the way home to exert full pressure. Air operated tools also available, in hand-held and bench-mounted types.

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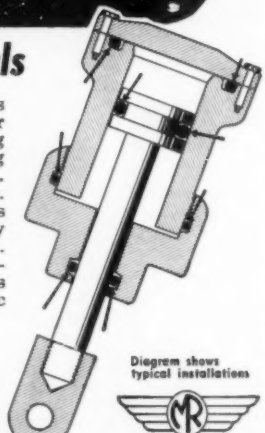

Diagram shows typical installations

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sioning of one hundred holes equally spaced around the periphery of a turbine wheel. The shop insisted on gaging each successive hole by the distance from a spring pin that dropped into the hole previously drilled. There was a lot of argument over this drill jig, but the superintendent won out to the extent that he was permitted to drill a scrap wheel. This he did and gleefully showed the finished job to the chief inspector, defying him to identify which was the last hole drilled. It looked like a perfect job.

The chief inspector simply handed the drilled wheel over to Bert, one of his bright young inspectors, with the order to find out what was wrong. About twenty minutes later, Bert called his boss to tell him that he was unable to find any error in the spacing of the holes but that there were 101 holes in the wheel instead of 100. And that was just too bad.

Gasoline-from-Coal Plant In South Africa

NEW YORK—Construction of the world's first modern, commercial, gasoline-from-coal synthesis plant will start in South Africa within the near future.

The plant, largest industrial project to be undertaken in South Africa since the last war, is being engineered and built for South African Coal, Oil and Gas Corporation Ltd. by the M. W. Kellogg Company. It will be located adjacent to the Vaal River about forty miles south of Johannesburg.

The project is an integrated plant which embraces the opening of virgin coal deposits to supply raw material; the construction of above-ground gassification facilities to transform coal into synthesis gas; and the complete synthesis plant, heart of the project, to produce liquid hydrocarbons.

Kellogg's SYNTHOL process is to be utilized in the synthesis step. This process differs materially from the processes used in previous synthesis plants for manufacturing gasoline and other liquid products.

The new plant, culmination of many years of planning by South African government and private interests, is primarily designed to produce liquid fuels—gasoline and Diesel oil—in volume. While South Africa does not possess any major indigenous petroleum reserve, it does have tremendous deposits of coal available that can be mined at low cost.

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SLEEVE BEARING APPLICATIONS

Simplified design and production savings can be effected in bearings, bushings and similar precision parts by designing the bearing when the engine or unit itself is designed. Re-design of bearings alone can sometimes be very helpful also. Our Engineering Department is prepared to provide this service—consult us without obligation.

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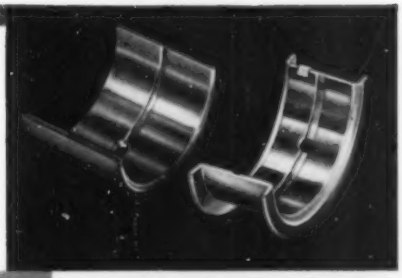
Many alloy variations are available. When design, alloy lining, back material and production method are properly combined, you obtain maximum performance at a practical cost.



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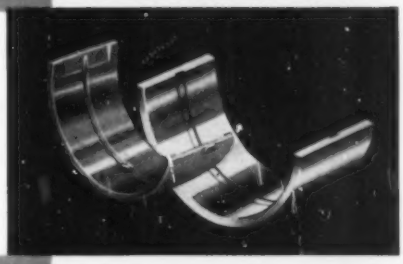
Copper-leads of similar chemical analysis can give radically different performance results. Our improved copper-lead metal powder and entirely new casting techniques for our cast bearings permit great flexibility to meet the widest range of requirements.



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For heavy-duty service we produce cast bronze bushings (and intricate precision bronze parts) to almost all bronze specifications. The rolled split-type bushing offers many economies where heavy-duty is not involved, provides substantial material savings while maintaining performance standards.

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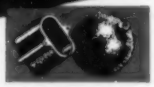
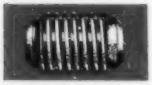
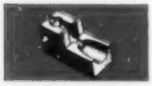


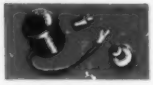
. . . as power and mercury arc rectifier tube anodes



. . . as bearings



. . . as molds and dies of many types



. . . as contacts for a wide variety of uses

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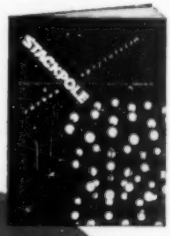

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MEETINGS

June 11-14

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Semi-Annual Meeting, Hotel Royal York, Toronto, Ont., Canada.

June 11-16

NATIONAL CONGRESS OF APPLIED MECHANICS—Sponsored by Illinois Institute of Technology, Chicago, Ill.

June 13-16

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS—Annual Meeting, Nicolet Hotel, Minneapolis, Minn.

June 18-20

SOCIETY OF THE PLASTICS INDUSTRY, INC., Pacific Coast Section—Eighth Annual Conference, Tahoe Tavern, Lake Tahoe, Calif.

June 18-22

AMERICAN SOCIETY FOR TESTING MATERIALS—54th Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 20-22

HEAT TRANSFER AND FLUID MECHANICS INSTITUTE—Stanford University, Palo Alto, Calif.

June 21-22

MALLEABLE FOUNDERS' SOCIETY—Annual Meeting, The Homestead, Hot Springs, Va.

June 22-23

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Applied Mechanics West Coast National Conference, Stanford University, Palo Alto, Calif.

June 25-29

AMERICAN SOCIETY FOR ENGINEERING EDUCATION—Michigan State College, East Lansing, Michigan.

June 25-29

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Summer General Meeting, Hotel Royal York, Toronto, Ont., Canada.

June 25-29

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Oil and Gas Power Division Conference, Baker Hotel, Dallas, Tex.

June 27-28

INSTITUTE OF AERONAUTICAL SCIENCES—Annual Summer Meeting, IAS Western Headquarters Bldg., Los Angeles, Calif.

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When writing, please use these felt specification numbers on your contracts.

This information is important, since in recent years there have been changes in Federal specifications for wool felts. American knows and will gladly work closely with you to see that Defense Orders for felt are filled with material that meets the requirements exactly.

Note These Specifications

Here are the three most important current specifications for wool felt.

Specification No.	Title
Federal Specification C-F-206	*Felt Mechanical Roll*
(Identical with S.A.E. Felt Specifications)	
Quartermaster Contracts	
MIL-F-10954 (Supersedes 8-15G)	*Wool Felt*
Air Force Contracts	
MIL-F-5656 (Supersedes AN-F-14a)	*Felt Wool*
(Identical with S.A.E. Felt Specifications)	

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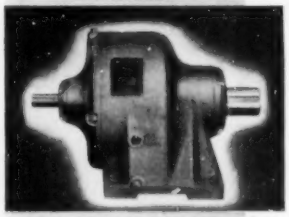
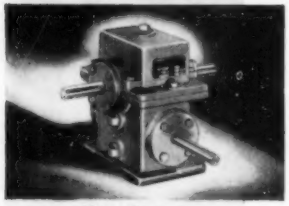
Helical Gear



Pat. Differential Gear

Worm-Helical Gear



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ENGINEERING ABSTRACTS

Color and Gloss Measurement

Abstracted from "Color and Gloss Measurements". Chemical Trade Journal and Chemical Engineer (London), Mar. 30, 1951, p 745.

THE DIFFICULT PROBLEM of measurement and specification of a color can be approached in several ways, of which the most accurate is a complete spectrophotometric curve. But this involves numerous measurements and elaborate and expensive equipment. In many applications, however, it is sufficient to obtain an "abridged" curve by measuring the reflectance in a limited number of regions of the spectrum which are isolated in turn by the use of narrow band optical filters.

Spectrophotometry Simplified

The "Eel" reflectance spectrophotometer, made by Evans Electroselenium, Ltd., London uses a special lamp, the light from which is focused by a condenser lens, through a heat-absorbing glass, to an optical filter wheel where any one of nine narrow band filters can be rotated into the beam in turn, the resulting illumination falling on the test surface at an angle of 45 deg. Light reflected from this surface is then collected by an "Eel" barrier layer photocell mounted directly above, the output from this cell passing a galvanometer. With this instrument, a curve showing the percentage of reflectance from the surface in various regions of the spectrum can be drawn. The filter wheel can easily be replaced by a three-color wheel if it is desired to record the color in terms of percentages of red, green and blue, or in terms of the CIE coefficients.

The measurement and specification of surface gloss is also difficult, since it is an attempt to express, numerically, a mental impression. The most complete physical data on the light-reflecting properties of a surface are given by a polar curve, though even this is generally obtained for only one angle of incidence of the light beam. Such measurements are laborious, difficult to correlate with visual estimations of gloss. In practice, therefore, an instrument is required which is simple to use and capable of giving, reproducibility, comparative readings

of gloss in agreement with visual judgment.

Evaluation of High Glosses

The "Eel" gloss head is a recent production in line with a specification laid down by the Paints Division of ICI. The instrument incorporates a precision lens system designed to give reproducible results and yet to detect small differences in samples of very high gloss.

The gloss head consists of a lamp housing, a cell housing and a plastic body accurately machined so that the main axis of the two housings are each at 45 deg to the surface under test. The lamp housing contains a 6-v, 3-w automobile-type bulb, so mounted that it can be accurately positioned by three adjusting screws. Light from this lamp is formed into a parallel beam by a precision lens and directed on to the surface under test at an angle of 45 deg. The specularly reflected light is collected by a second lens, mounted in the cell housing, and forms an image of the lamp filament at an aperture in a diaphragm mounted in front of the photocell. This aperture is slightly larger in size than the image of the filament and serves to cut off light not reflected specularly from the sample. The gloss head is connected by a flexible 4-core cable to the galvanometer unit through a plug-and-socket connection.

Surface-Brightness Assessment

An accurate assessment of surface brightness can also now be made with the "Eel" P. R. S. reflectance head, developed in cooperation with the Paint Research Station and which can be operated as an interchangeable unit from the same galvanometer unit employed with the reflectance spectrophotometer and the gloss head. The P. R. S. reflectance head provides an improved reflectometer with precise linear characteristics for the measurement of diffused reflection. Measurement of the opacity of paper, paint films or other thin translucent solids can conveniently be made by taking reflection measurements through the sample first over a white and then over a black standard.

Young's Modulus at Elevated Temperatures

Abstracted from The Engineer—Sept. 29, 1950, p 325.

THIS ARTICLE DISCUSSES recent work conducted in England, the United States and in Germany where certain

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The phenomenal growth and acceptance of the MICROCAST PROCESS within the short space of 22 years indicates only a bare surface-scratching to date of its potential development. Those small beginnings in the dental and surgical appliance field, hastened by wartime demands, paved the way for eventual industrial application.
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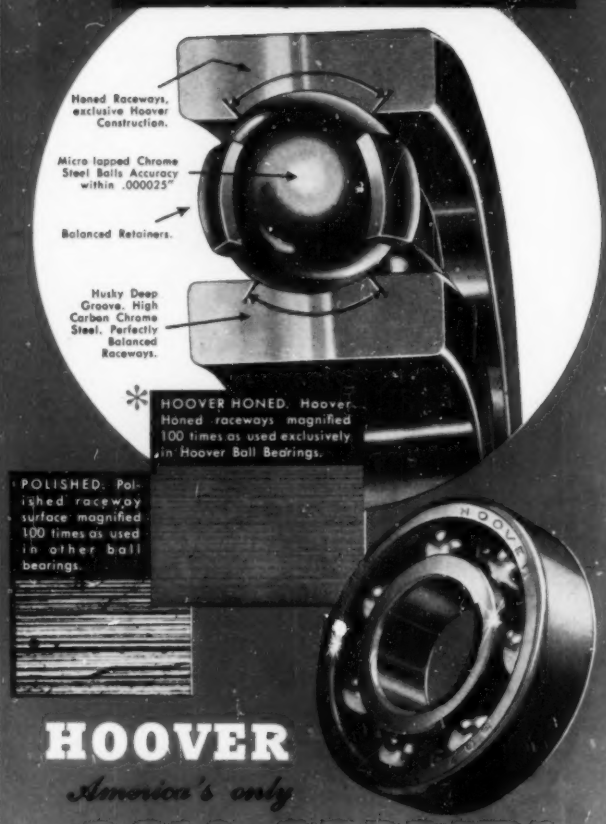
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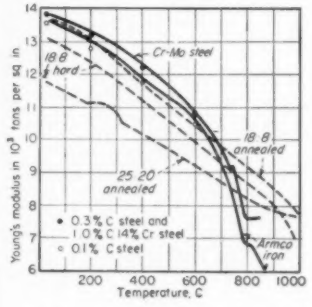
relationships have been developed to express the behavior of various metals and alloys at high temperatures. Köster[1] found that the modulus at a given temperature plotted against the ratio of the temperature to that of the melting point (both on the absolute scale) showed an almost linear relationship over a wide range of temperatures.

Jones and Nortcliffe[2] were able to show that the modulus of ferritic steel at a high temperature was a constant fraction of its modulus at room temperature. Similarly, the modulus of certain austenitic steels at a given temperature was a constant fraction of the value at room temperature. These fractions or factors were slightly smaller than for the ferritic steels and bore a linear relationship to the temperature: In Table I, this factor is listed and the slight differences between calculated and experimental values are shown.

Measurements of the modulus of elasticity of a variety of materials have been carefully made by C. W. Andrews[3]. The dynamic method of testing was similar to that used in England. The materials tested included Armco iron, chromium-molybdenum steel, several types of austenitic steel, Inconel, Stellite and an aluminum alloy. The results are illustrated in Fig. 1. Note the good agree-


Young's modulus in 10^3 tons per sq in.
Temperature, C
Cr-Mo steel
18 8 hard
18 8 annealed
25 20 annealed
• 0.3% C steel and 1.0% C 14% Cr steel
○ 0.1% C steel
Armco iron

ment between the Armco iron and the points of a 0.1 percent steel.

One curious feature was observed in a Cr-Ni-Co cold rolled sheet: there was a marked difference between the longitudinal and transverse modulus. These values were:

Longitudinal

$$E_L = 12{,}000 - 4\ (t - 20)$$

Transverse

$$E_t = 13{,}700 - 5\ (t - 20)$$

where E is in tons per sq in. and t is in deg. C.

It would appear that these values were affected by internal stresses. However, these values converged at

high temperatures and both showed a rapid decrease at about 800 C due to softening as well as a decreased resistance to creep.

Results on an aluminum alloy (Zn 5.5, Cu 1.5, Mg 2.5, Cr 0.3 and Mn 0.2 percent) gave results very similar to Köster's values for aluminum, all of which approximated closely to the value: $E = 10.5 - 0.0067\ (t - 20)$ in million lb per square inch.

References

1. Zeit. für Metallkunde, vol. 39, pages, 1, 8, 111, 145.
2. Journal of the Iron and Steel Institute, 1947, vol. 157, pages 345 and 535.
3. Metal Progress, July, 1950, page 85.

Table I—Young's Modulus for Ferritic and Austenitic Steel (in thousands of tons per sq in.)

FERRITIC

Temp C	Armco Iron		Cr-Mo Steel		Factor
	Exp.	Calc.	Exp.	Calc.	
20	13.5	...	13.7	...	1.0
200	12.9	12.8	13.2	13.0	0.948
400	11.8	11.8	12.2	12.0	0.875
600	10.5	10.5	10.8	10.6	0.775

AUSTENITIC

	18-8 Type Annealed		18-8 Type ½ Hard		25-20 Type Annealed		Factor
	Exp.	Calc.	Exp.	Calc.	Exp.	Calc.	
20	13.7	...	13.0	...	11.7	...	1.0
200	12.4	12.7	12.4	12.1	11.0	10.9	0.930
400	11.7	11.6	11.1	11.0	10.2	9.9	0.845
600	10.5	10.5	9.9	9.9	9.2	8.9	0.762
800	9.2	9.3	8.7	8.8	8.3	7.9	0.680

Protecting Machined Parts From Corrosion

Abstracted from Mechanical World (London) Jan. 19, 1951, p 49.

MOST CORROSION PREVENTIVES function by providing a water resistant barrier and by forming an absorbed layer of inhibitors on the metal. Without special inhibitors a film is likely to fail quickly if it gets thin.

These protective materials can be divided into soft-film, hard-film and oil-film types, the soft films being further divided into solvent-deposited, hot-dip, smearing and slushing types.

Soft-film and Hard-film Materials

Films deposited from a solvent after cold application are usually lanolin or petrolatum mixtures dispersed in such solvents as white spirit of coal-tar naptha.

A soft-film applied by hot dipping and based on petrolatum (sometimes called mineral jelly) may vary from a relatively hard, almost waxy, consist-

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ency to one nearly as soft as the petroleum jelly sold for pharmaceutical purposes. Protection depends on the blanket effect of a film of the order of 0.5 mm thickness and will last for upwards of 10 years if the film is uniform; but it is difficult to attain this uniformity in practice. The addition of a corrosion inhibitor permits the film thickness to be reduced.

Smearing materials for cold application are usually lubricating greases, i.e., blends of soaps and lubricating oil, but can be mixtures containing petrolatum, oil, lanolin or other fatty material.

The slushy compounds flow at ordinary temperatures and when applied by a brush smooth out. Some contain a solvent which evaporates and leaves a stiff protective coat.

Hard films are deposited cold from solvents, and after drying should be tough, and neither sticky nor brittle. They contain plasticised resins or bitumens. For quick drying, petrol-type solvents are used; if inflammability is not acceptable then the solvent must be of the carbon tetrachloride or thrichlorethylene type, which have in turn the disadvantage of being toxic. If slow drying is tolerable then white spirit of coal-tar naptha is satisfactory.

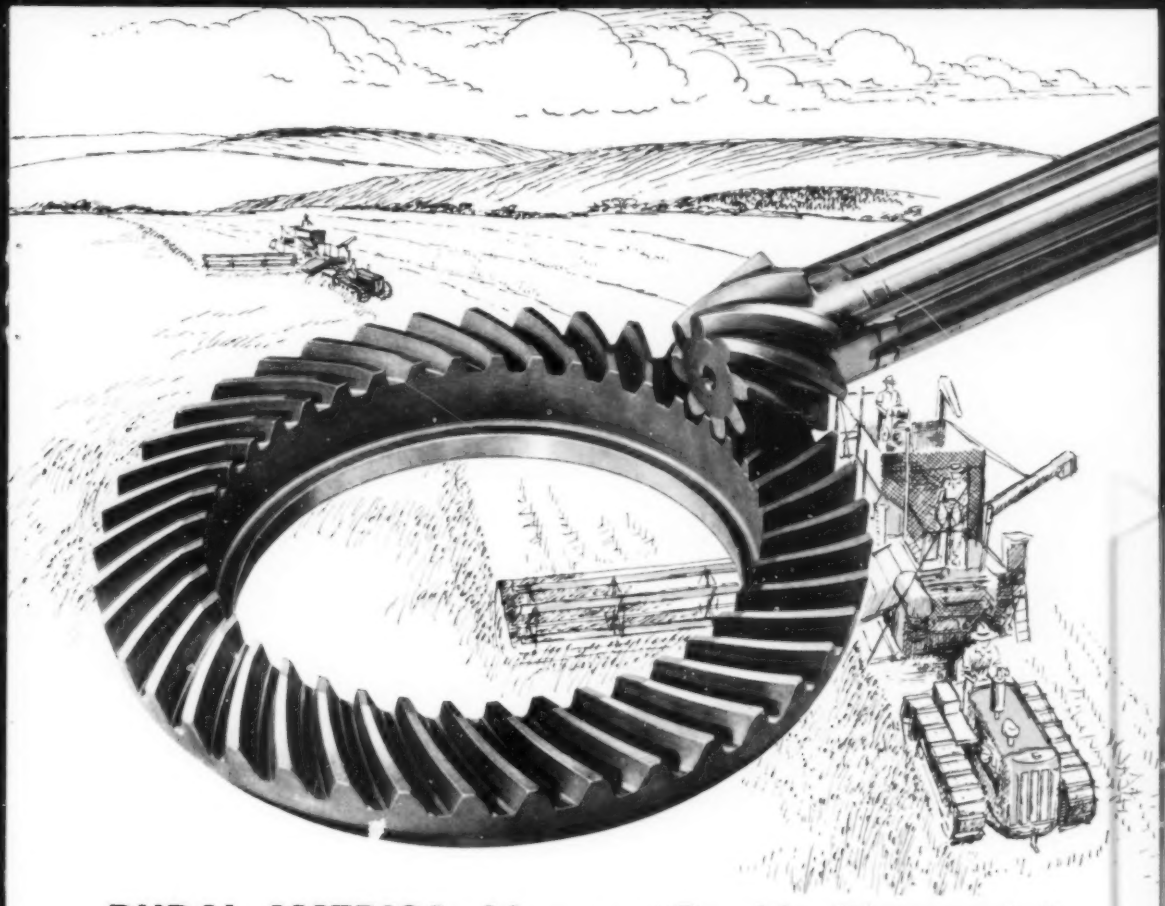
Oil Types

Oil fluid films are mineral oils of medium or low viscosity and contain specific rust inhibitors. They have definite usefulness on internal surfaces of tanks and certain assemblies, and on parts where solid material or solvents could not be tolerated. Sometimes the oil must also serve as a lubricant, as in hydraulic systems; in some cases in engines where there will be contact with leaded-fuel residues and where there will be a need of special inhibitors for these circumstances.

Hot-dip, Strippable-Coating Protective

This material is generally based on ethyl cellulose. The coating is low in specific rust inhibiting properties, but is thick and tough thus providing an impervious barrier to moisture and also giving good protection against mechanical damage. The material is expensive, but because packaging materials are saved the total cost is not high. Thinning does not occur at points of contact so that overall protection is generally better.

An attempt is being made to provide strippable films which can be deposited cold, but these films are generally much thinner, more fragile and not nearly so easy to strip. There is promise of a strippable material using rubber latex dispersed in water,



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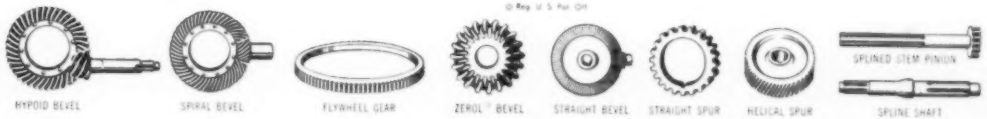

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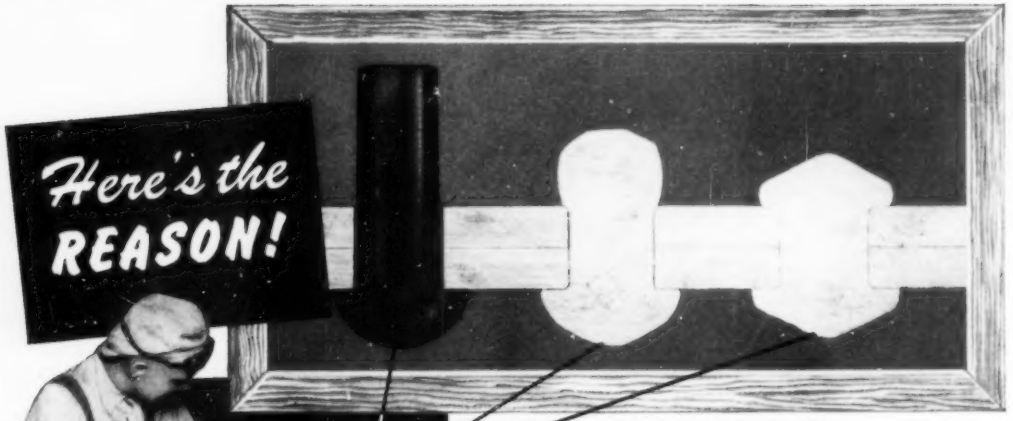

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Castor oil grease is used for metal components associated with rubber, e.g., anti-vibration bushes, certain hydrulic apparatus components. Aqueous inhibitors are sodium benzoate and sodium nitrite, and certain phosphates can be used to advantage with sodium nitrite. Sodium nitrite is so cheap that large tanks can be filled with the 0.2 percent solution. Strong solutions can be made up into pastes for protective purposes.

Scope of Materials

Paints and varnishes should be applied wherever possible. Temporary corrosion preventives should be used only where removal is subsequently necessary. In their normal thicknesses, the general run are unsuitable for outdoor exposure and they should always be protected against gross liquid water by appropriate coverings or wrappings. An exception is the petrolatum-based, thick film materials, and in some cases grease, which can be employed to protect equipment stored outside if applied in extra thickness and if the crevices are filled. Water should be kept out of contact with temporary corrosion preventives.

It is vital that the protective coating should be applied to clean and dry surfaces. Where there is exposure to salt-spray, it may be necessary to test the protectives specifically for their resistance to salt-water corrosion.

Causes of Failure

The causes of failure of temporary corrosion preventives are classifiable thus: (1) Inherent inadequacy of the material; (2) inevitable difficulties in application; (3) carelessness in application; (4) exposure to unreasonably severe conditions.

There are numerous accessory causes of failure which are to be avoided. Hard films may be brittle and flake off on casual contact of articles with each other; they may remain too sticky, thus becoming particularly liable to get dirty, and to make wrapping-paper stick to them and pull the film away from the metal; they may age to an insoluble condition and thus become difficult to remove with the common petroleum solvents. Soft films may

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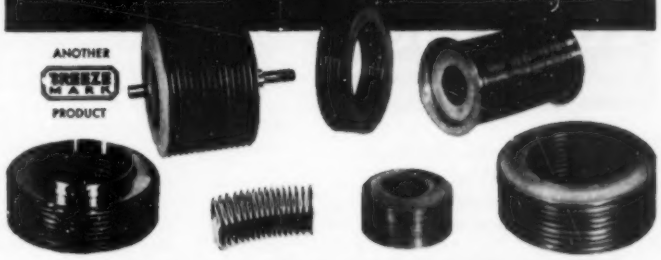

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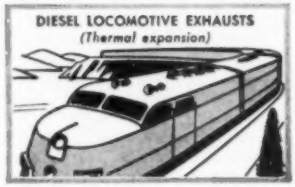

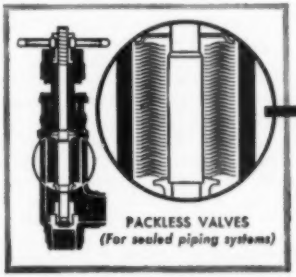

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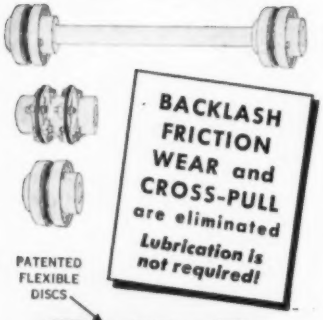

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have too low a melting point for tropical conditions; hard films may not remain flexible and adherent at low temperatures, and particularly at the very low temperatures obtaining during air travel. Moreover there is an obvious need in general for good wetting properties on the part of the material as applied; there must be good adhesion after evaporation of the solvent or after setting; and the material must acquire the intended consistency or must dry in the required time.

Choice of Protective

Hard film protective can be applied to all kinds of single articles, but not to assemblies or they will be cemented together. Crankshafts, camshafts and layshafts of engines; cylinder liners; and gears (but not gear assemblies) are examples. Many articles treated with hard film are shipped without wrapping, but if wrapping is required it is important to protect points of contact and to use a non-corroding (in particular a chloride-free) inner wrapping paper.

Soft film protective can be used broadly for the same purposes as the hard film, except that it should be given more protection in subsequent packaging. A grease-proof paper is required for the inner wrapping.

Thick soft films are essentially applicable to heavy-duty assemblies such as piston assemblies, road springs and spring leaves, brake cables, ball and roller bearings.

Lime base grease applied by a brush is especially suitable for composite wood and metal assemblies, and articles usually painted, but have certain working surfaces which must be treated with grease.

The slushing material finds its most useful application on large heavy machinery requiring protection of large areas either during storage or during intervals of idleness in machine-shops. The effect of dust and dirt contamination should, therefore, be a factor taken into account when assessing the values of these materials.

The oil type protectives, being lower in protective quality than the solid film types, are generally restricted to internal surfaces where the article itself acts, so to speak, as its own wrapping. Thus internal combustion engine cylinders are sometimes sprayed with the oil type protective through the spark plug hole or the injector hole. Tanks and other containers can also be rinsed out with this material. There is also a wide use for it as a protective lubricating oil, thus fine mechanisms can be lubricated with this material on assembly so that all

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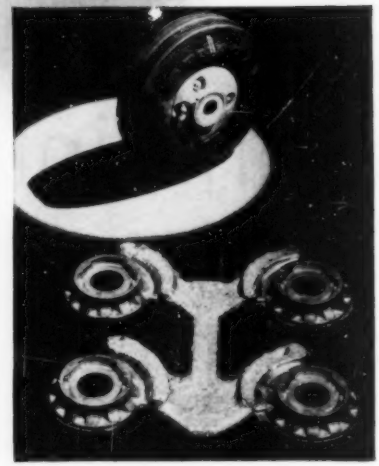

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the parts that are oiled are given a somewhat increased measure of protection against corrosion. In a few cases, the complicated internal parts of a mechanism can be oiled, and then the article can be dipped in the hot-dip petrolatum type protective to provide an outer protective coating. Because the article itself acts as a wrapping, the additional packaging that would normally be required to supplement this weaker kind of corrosion preventive is not required. Exceptions are small articles which cannot easily be protected by the solid-film type of corrosion preventive, and they are, therefore, dipped in oil and wrapped in some sealing type of envelope, so as to restrict the amount of moisture that can get through to the articles themselves.

The hot-dip strippable coating is applicable wherever a high standard of protection is required and where advantage can be taken of its help against mechanical damage. So far there has been particular use for gauges and tools, which so often have their working surfaces facing outwards. Assemblies can be coated provided their recesses are not so large that the thick melt can penetrate in dipping and thus prevent the coating being stripped easily.

Quite a number of articles are not adaptable to oil or grease films, particularly instruments. Reference has already been made to vapor-phase inhibitors. By wrapping the articles in impregnated paper, it is possible to protect many such instruments or mechanisms. Some care is necessary at this early stage of the development of this material because there are questions to be answered, particularly in the case of some non-ferrous metals. The alternative to the vapor-phase inhibitor is hermetic sealing with suitable wrappings, all joints being carefully made and a quantity of desiccant being contained within the package. There is much complicated electrical and electronic gear which can be protected satisfactorily only in this way.

Where large components are involved, much attention has been given to what is called "cocooning." First a web-like frame-work is made by spraying threads over the article, thus bridging gaps, and providing a base for the impervious layer which provides the barrier to water vapor. As with the other types of packages, quantities of silica gel can be included within the cocoon covering.

It is of the utmost importance that the originator of the products should apply protection. It should not be left as something to be done at a later stage in the life of a component.

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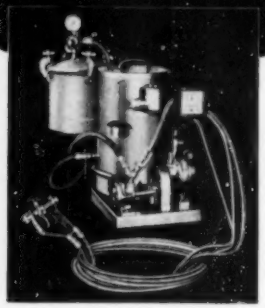

PROBLEM: Specify a motor to drive liquid pump at variable speeds, for Bede Circulating Paint Heater. (A unit for faster, more uniform application of hot finish.)

SOLUTION: A Gast Rotary Air Motor, running below 500 r.p.m., drives pump at 150 r.p.m. Uses less than 30 p.s.i. air pressure.

RESULT: Power that's economical, dependable, safe. With explosion-proof Gast Motor, entire unit was approved by Underwriters' Laboratories.

Your problem may be entirely different — yet the *unique advantages* of Gast Rotaries may offer just what your product requires. In sizes from 1/20 to 3 h.p., Gast Air Motors are amazingly compact and light in weight. And overloads can't burn them out!

Write Gast, describing your original equipment application. We'll send full details. "Air may be your Answer!"

Gast Application Ideas Booklet—showing 26 design problems solved—sent upon request.

see our CATALOG in SWEET'S FILE

Original Equipment Manufacturers for Over 25 Years

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AIR MOTORS (TO THREE H.P.) · COMPRESSORS (TO 30 LBS.) · VACUUM PUMPS (TO 28 INCHES)

GAST MANUFACTURING CORP., 139 Hinkley St., Benton Harbor, Mich.

OUR READERS SAY

Here's A Problem

To the Editor:

Perhaps you can help me with a problem which has been handed to me.

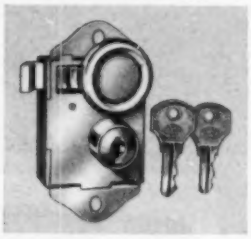
As shown in the figure, a certain piece of apparatus with which we are working has a vertical disk on which a roller exerts considerable push toward the left at the top while a similar roller pushes with equal force to the right 180 deg from the upper roller, or at the lower part of the disk. As the disk rotates, rather rapidly, it is obvious that any given point on the rim of the disk is pushed first one way and then the opposite, causing a flexing movement with the hub and shaft at the center.

This arrangement is almost identical to the disk drive which was applied to some early automobiles and still is found on some blue print machines and dryers, the only difference being that our job has two wheels riding on the disk.

Although a heavy disk is used, failure soon takes place near the hub. Someone has suggested that a laminated (three or four layer) disk be used instead of one piece of plate, on the theory that thin pieces of metal, such as a metal tape measure, can be flexed many times whereas a thicker piece of the same material would break after a comparatively few cycles. I believe this to be true, in certain instances, but have not reconciled myself to such a thing as being the solution to our problem.

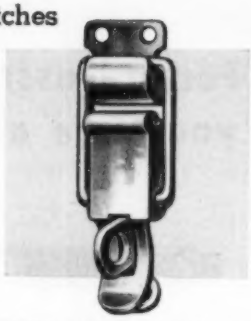
I have a vague remembrance of having seen or studied a formula which would be applicable to such a problem as this, my memory seeming to call up a relationship involving inverse ability to flex as to the squares of the thickness (for a given width). The squared relationship applies inversely to the carrying capacity of a leaf spring, but I am unable to find in any of my books or reference files any data pertaining to the ability to flex (length of life) of a spring, which data I would be willing to accept as applicable to this particular problem. Perhaps it is only wishful thinking, but didn't PRODUCT ENGINEERING have an article right along this line, some time ago? If so, and you can

Panel Board Locks



Padlocks

Catches



CORBIN standard or special locks and catches

NOW, when you may be converting a part of your production to meet military as well as civilian needs, the training and experience of Corbin sales engineers can save you time and money. We shall be glad to work with you on lock or hardware items suitable to all of your requirements. In most cases we can suggest an item already being produced . . . in others, we'll cooperate in developing special locking devices.

BE SURE . . . with CORBIN

CORBIN CABINET LOCK DIVISION
THE AMERICAN HARDWARE CORPORATION
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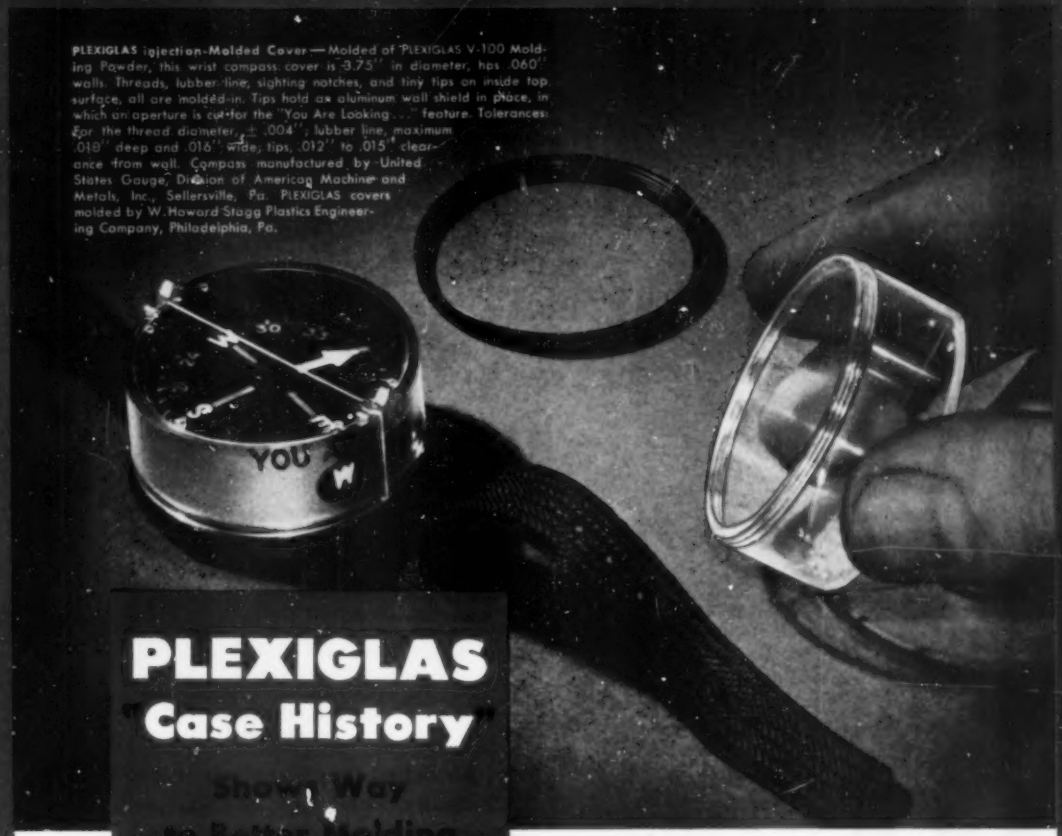

PLEXIGLAS Injection-Molded Cover—Molded of PLEXIGLAS V-100 Molding Powder, this wrist compass cover is 3.75" in diameter, has .060" walls. Threads, lubber line, sighting notches, and tiny tips on inside top surface, all are molded-in. Tips hold an aluminum wall shield in place, in which an aperture is cut for the "You Are Looking . . ." feature. Tolerances: for the thread diameter, ± .004"; lubber line, maximum .018" deep and .016" wide; tips, .012" to .015" clearance from wall. Compass manufactured by United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Pa. PLEXIGLAS covers molded by W. Howard Stagg Plastics Engineering Company, Philadelphia, Pa.

PLEXIGLAS "Case History"

Shows Way to Better Molding

This transparent cover for an Air Force wrist compass *could* have been a headache to its molder. Specifications required optical clarity, outdoor durability, resistance to heat and impact, and molding to *precision* tolerances. The selection of PLEXIGLAS V-100 for the job was a logical solution to this combination of problems.

PLEXIGLAS acrylic plastic molding powders can solve *your* problems, too. Their excellent flow characteristics permit satisfactory molding over a wide range of temperatures and pressures. From small parts to large sections, molders report good production rates.

PLEXIGLAS V-100 is only one of the Rohm & Haas "V", "VM", and "VS" formulations now going into defense applications. Headlight lenses for amphibious military vehicles, blackout lenses, transparent containers for medical supplies, barracks windows, aircraft radio antenna housings, are being molded of PLEXIGLAS Molding Powders. We'll be glad to send you full details of these acrylic plastic powders.

CHEMICALS FOR INDUSTRY

• A steadily increasing percentage of PLEXIGLAS production, now at record levels, is required for the defense mobilization program. The supply available for civilian applications is limited.

PLEXIGLAS *is a trade-mark, Reg. U.S. Pat. Off. and in principal foreign countries.*

Canadian Distributor:—*Crystal Glass & Plastics, Ltd. 54 Duke Street, Toronto, Ontario, Canada*

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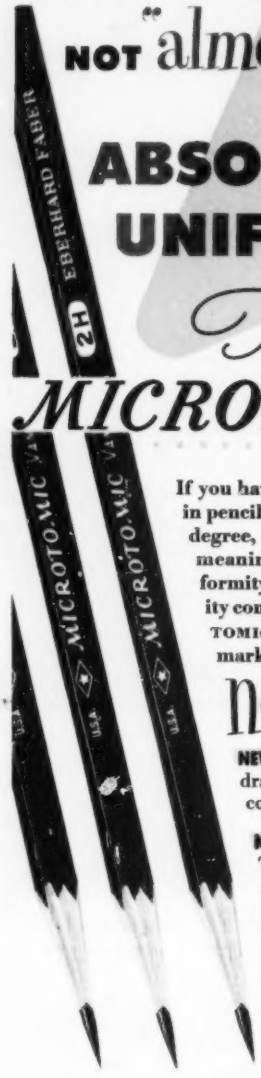
Representatives in principal foreign countries

NOT "nearly"...
NOT "almost"...BUT

ABSOLUTELY UNIFORM

The all-new
MICROTOMIC



If you have ever found a variance in pencils stamped with the same degree, you will appreciate the meaning of MICROTOMIC uniformity. Newly developed quality controls make *every* MICROTOMIC of the same degree marking identical.

New FEATURES YOU HAVE WANTED!

NEW DUSK GRAY...hundreds of draftsmen said it was the best color for a drawing pencil!

NEW 'BULL'S-EYE' MARKING The degree is marked on 3 sides—never out of sight!

NEW PRINT CLARITY...Hi-Density lines that are exceptionally opaque to the actinic rays of high-speed 'printers'...dead-white, feather-free, no-blur lines!

NEW SMUDGE FREEDOM Fewer loose, smeary graphite particles in MICROTOMIC lines!

TRY THE "3-against-3" test

Test 3 All-New Microtomics against 3 of your present drawing pencils. *Find out* what brand is more uniform. Your Dealer has MICROTOMICS. Order some—test them—today!

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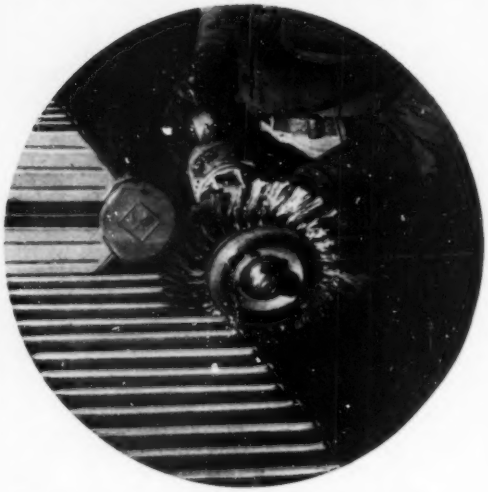
EBERHARD FABER

How a Pittsburgh Brush Solved an Oil Pressure Problem*



*** An actual case history from the Allis-Chalmers Pittsburgh Works, manufacturers of Transformer Radiators.**

At Allis-Chalmers, well-known manufacturer of industrial equipment, the problem was to secure a satisfactory oil pressure test on transformer radiators. The key to the problem was to find a brush narrow enough to clean between cooling fins and strong enough to remove slag and spall on welds which could conceal pinholes. Pittsburgh engineers recommended an 8" rotary wire brush. The brush proved more than satisfactory and the problem was solved!

Let Pittsburgh Engineers Solve Your Brush Problems.

Pittsburgh's complete line of brushes of every type, for every purpose, will provide a practical and economical solution of any brush problem you might have. Drop us a line on your company letterhead for a copy of our new booklet that shows, through actual case histories, how Pittsburgh can help cut your brushing operation costs. Address: PITTSBURGH PLATE GLASS COMPANY, *Brush Div.*, Dept. W2, 3221 Frederick Ave., Baltimore 29, Md.

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give me dates, I have complete files for at least ten years back. Any information you can provide will be greatly appreciated. —L. H. A.
Butler, Pa.

Ed—Unfortunately, we cannot recall any past articles which might have discussed this type of problem. If you could supply us with more specific information about this problem, we may be able to suggest how these failures might be eliminated. Can you describe the nature and magnitude of the loads? At what speed is this disk rotating? What is the size of the disks and are there any space limitations? What materials are you using and how long is it before failures occur? In the meantime, we felt that our readers might have some ideas on this problem. Well designers, what would you do in this case?

There Ain't No Such Outfit

To the Editor:

Thank you very much for the tear sheets on your April editorial. I think the thoughts expressed therein are particularly timely now when there is an urgent need for engineers in government work—and not a little indication that the new crop of engineering school graduates would prefer the higher wages paid by industry.

I also want to enter a plea for better printed identification of the various military organizations. Undoubtedly, most of your readers will know that "Bureau of Aeronautics" and "Ordnance Department" refer to Navy and Army respectively, but there are some, unfamiliar with internal affairs of the services, who might benefit by such titles connected to those old and honorable words, Navy and Army. As for that third group mentioned in your editorial—I'm afraid this will be only the first letter pointing out that ever since 1947, when the Air Force was made the third military service, there hasn't been any Army Air Corps.

—Arnold S. Lott
Department of Defense

Broadens the Scope of Oil Mist Lubrication

To the Editor:

We were very much surprised to read in the May number in the article by R. J. S. Pigott the statement that, "Oil-mist lubrication is good, if confined to high speed bearings." From our experience with oil-mist lubrication we find it to be a superior type for

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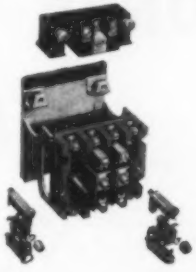
SIZE
Non-Reversing
2 to 4 Pole 2-3/4" w. x 3-5/8" h. x 3-5/16" d.
5 to 8 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.
Reversing
2 to 4 Pole 5-9/16" w. x 3-5/8" h. x 3-5/16" d.
Note: 10 and 15 ampere contactors have same mounting and overall dimensions.

ACCESSIBILITY
To replace contacts, it is not necessary to disassemble the complete contactor. Just remove the parts comprising the stationary and movable contacts. Contacts can be replaced without disturbing wiring. To change coil, remove magnet frame and coil assembly only. (See illustration below.)

FLEXIBILITY
Using a screw driver only, you can easily change any pole from normally open to normally closed. No special parts required. 10 and 15 ampere parts are interchangeable.

RELIABILITY
Laboratory tests involving millions of operations, plus field service of thousands of R-B-M contactors on door operators, radio transmitters, packaging and weighing machinery, hoists, machine tools and many other industrial applications offer proof of dependable, trouble-free performance.

ADVANCED DESIGN
Melamine Insulation. Molded coil housing. Ilsco solderless connectors. 50/60 cycle magnet coils. Palladium silver contacts. Stainless steel self-contained contact springs.



Where space is a factor, and accessibility a must—use R-B-M industrial contactors. Initial low cost plus dependable performance will save you money. Write for Bulletin 600 and price list on your company letterhead.
Address Dept. C-6

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MANUAL AND MAGNETIC ELECTRIC CONTROLS
FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

THE RIGHT BALL

Let Strom Help You

Not only in precision ball bearings, but in countless other places, Strom has found that the right ball will do the job better. Maybe your problem can be solved with the use of the proper ball. Why not take it up with Strom.

Strom has been making precision metal balls for over 25 years for all industry and can be a big help to you in selecting the right ball for any of your requirements. In size and spherical accuracy, perfection of surface, uniformity and dependable physical quality, there's not a better ball made.

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Largest Independent and Exclusive Metal Ball Manufacturer

10-Horsepower!

ONLY 97 lbs.

ONAN CK ENGINE

STEP UP PERFORMANCE of your engine-driven equipment with this rugged, lightweight prime mover. The Onan 10 HP Two-Cylinder 4-Cycle CK engine is inherently smooth-running delivers vibration-free power at all speeds. Alternate-firing, air-cooled. Built for long, heavy-duty service . . . with oversize bearings and rugged construction throughout. Unusually compact, to simplify installation.

OPPOSED DESIGN: Lighter weight, vibration-less performance.
OVER-SIZE BEARINGS: Extra-large bearing area assures longer life.
PRESSURE LUBRICATION: Positive oil supply to all bearings.
SHORT, RIGID CRANKSHAFT: Fully counter-weighted.
AXIAL FLOW COOLING FAN: Forces air over and around cylinders for maximum efficiency.

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lubrication of ball and roller bearings and also for high speed gears. By using oil-mist, we make certain that there will not be too much oil churning around in the ball and roller bearings. The author states that the oil-mist results in lubrication about half way between liquid oil and the Kingsbury air bearing. That is perfectly correct but it should be added that the Kingsbury air bearing is of a highly special type and not applicable in industrial products in general. Therefore, it is not generally used in spite of the extremely low coefficient of friction that results when air is used as lubrication. —C. A. S.

Denver, Colorado

Ed—We have just about reached the point where we believe in mental telepathy. Unfortunately in the editing of Mr. Pigott's manuscri , several editorial liberties were taken, and the manuscript got on the press before we received Mr. Pigott's revised manuscript. His revisions are exactly in line with the criticisms expressed above. Our apologies to Mr. Pigott and our readers. We will shortly have a comprehensive article on this subject, which will clarify everything.

Electrodynamic Shakers

To the Editor:

The Arsenal Library would appreciate authorization to reproduce the following for Library files:

Test Techniques Using Electro-Dynamic Shakers; R. C. Lewis

PRODUCT ENGINEERING 22: 142-47 February 1951

FOR THE COMMANDING OFFICER: —V. P. MURPHY
Lt. Col., Ord. Corps
Pitatinny Arsenal

Ed—We are glad to extend to you permission to reproduce the article. Thanks for the compliment.

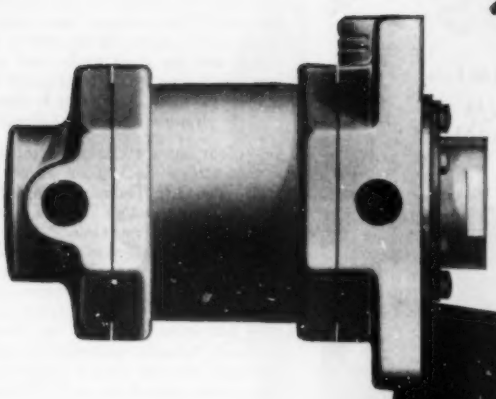
Out Like a Light

To the Editor:

The Argonne National Laboratory is interested in obtaining 100 copies of the following article, which appeared in a recent issue of PRODUCT ENGINEERING:

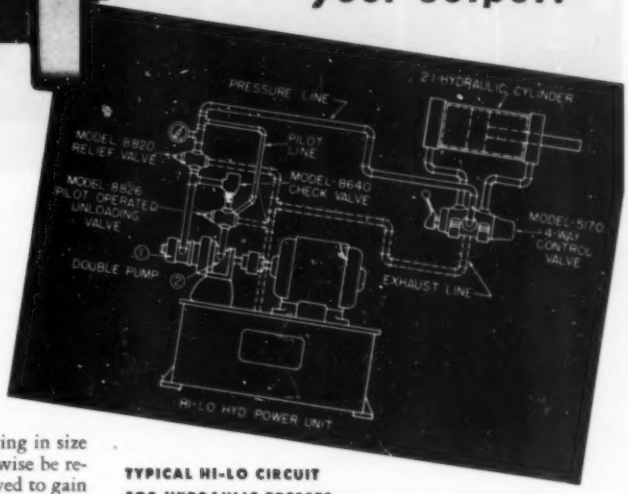
"Simplified Helical Spring Design", by Carl Thumim and H. A. Reiter. PRODUCT ENGINEERING, March 1951, pages 136-140 and 6-page chart following page 140.

We are writing to inquire if reprints of the above article, including the folding chart, are available for



Double the Rod Size –

and increase your output!



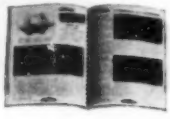
RIVETT 1500 P.S.I. HYDRAULIC 2:1 CYLINDERS have a piston rod about twice as large as standard cylinder rod size. The larger rod reduces oil displacement, permitting it to retract at twice the speed that it extends. This speed-up shortens cycle time, allowing the rod to extend again quickly, thereby accomplishing more work!

This faster speed is gained with a saving in size of motor and pump which would otherwise be required. 2:1 cylinders may also be employed to gain identical retracting and extending speeds, as well as to support larger loads where straight linear motion is used.

Available in 6 standard mountings: Foot, Trunnion, Center Line, Blind End Flange, Rod End Flange, and Clevis; in 10 bore diameters; in any stroke up to 96"; and with cushioning.

Remember—Rivett Hydraulic Cylinders have Keeper ring design, permitting the cylinder to be rotated to convenient pipe connection.

Send for Catalog Section No. 105 illustrating and describing all types and sizes of Rivett Hydraulic Cylinders.



TYPICAL HI-LO CIRCUIT FOR HYDRAULIC PRESSES

This circuit illustrates a press application where rapid speed and low pressures are required for the major portion of the stroke and high pressures are required for the "squeeze" portion of the stroke. The output of both the low pressure high volume pump (2) and the high pressure small volume pump (1) is directed to the hydraulic cylinder at a low operating pressure. When sufficient work load builds up, pressure in the system increases and the model 8826 pilot operated unloading valve unloads the output of pump (2) while the output of pump (1) is still directed to the cylinder. Direction of piston travel is controlled by model 5170 4-Way control valve. The horsepower requirement for this type of circuit is much less than if a single pump of sufficient volume and pressure for the application were used.

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AIR AND HYDRAULIC VALVES AND CYLINDERS, HYDRAULIC POWER UNITS

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. . REDUCE FINISHING TIME—
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Shown above are three presses ranging from 250 to 600 ton capacities, another important part of Unitcast's facilities that add quality to the product.

- **Do your castings assemble freely and within tolerance limits?**
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- **Are your finish allowances held to a minimum?**

INTERCHANGEABILITY has long been recognized as the forerunner of mass production. Unitcast daily production is held to the specified dimensional tolerances, assuring you this very important advantage.

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Give us a chance to offer a "cast steel" answer for your parts problem. Our suggestions while your product is in the design stage will pay continuous dividends. Write or call today. Unitcast Corporation, Steel Casting Division, Toledo 9, Ohio. *In Canada:* Canadian-Unitcast Steel, Ltd., Sherbrooke, Quebec.

UNITCASTINGS ARE FOUNDRY ENGINEERED

purchase. If reprints are not available, we should like to know how much it would cost to have 100 reprints of the article and the chart made, and also how much time would be required for delivery. —EDWARD F. SMITH
Argonne National Laboratory

Ed—Your letter of April 12 requesting quotations on 100 copies of the article by Carl Thumim "Simplified Helical Spring Design" creates a little embarrassment in our ranks.

Since this article was done by our regular printer and since we were limited the quantity of charts that were printed, we found ourselves with very few extra copies of the article on hand. Actually, we started out with well over 800 but several hundred of these were gobbled up by ITE Circuit Breaker Company.

To reprint the article for you, even in such small quantities as 100 copies, would cost you a small fortune. May I suggest the following: That you contact Mr. Thumim at ITE Circuit Breaker and request from them a limited number of copies. They have I believe something like 600 or 700 complete reprints and perhaps if you would scale down your demands, they would be willing to supply you.

Reinforced Plastics Aid No Matched Molding Data

To the Editor:

We have just finished reading Mr. Francis' article on reinforced plastics in your February 1951 issue. We believe his article is quite complete. We do not believe that he spent as much time on the subject of molding in matched metal dies as he should have. Most other methods of molding he described are generally for low production specialized items. The high production low cost items such as we make are made in matched metal telescoping dies.

We note that you say that reprints of this article are available. We believe it would be a good article to have our general employees read, as it might help orient them in the field. Will you send us a quotation on 100 of these reprints —R. S. MORRISON
Molded Resin Fiber Co

Ed—In lots under 100, this insert sells for 25c per copy and in lots of 100 or more for 23¢ per copy. For your purposes, therefore, the price would be $23.00.

You picked out in your letter one of the weak points in the article, namely, the lack of detail on molding

Tubing troubles got your goat?

Bundyweld Tubing, double-walled from a single strip. Exclusive, patented beveled edge affords smoother joint, absence of bead, less chance for any leakage.

If you're butting up against costly rejects, time-taking inspections, poor performance in your tubing unit, you ought to get the facts on Bundyweld.

This multiple-wall type of Bundy® tubing is double-rolled from a single strip, unmatched by any other tubing.

It's amazingly rugged, easy to form and fabricate. It conducts heat faster, and withstands gruelling vibration in lines and coils that have to take a shaking.

Right now, defense and essential production rate top call on Bundyweld, though we're doing everything possible to service all Bundy customers. Why not inquire regarding your needs?

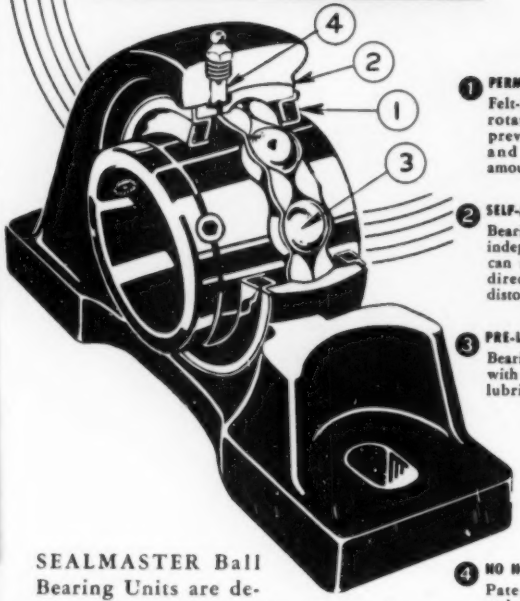
Bundy Tubing Company

DETROIT 14, MICHIGAN

World's largest producer of small-diameter tubing

AFFILIATED PLANTS IN ENGLAND, FRANCE AND GERMANY

DEPENDABLE
outstanding features assure unexcelled performance from
SEALMASTER
BALL BEARING UNITS



1 PERMANENTLY SEALED! Felt-lined steel flinger rotating in labyrinth prevents entry of dirt and retains proper amount of lubricant.

2 SELF-ALIGNING! Bearing unit, with seals independent of housing, can align itself in any direction without seal distortion.

3 PRE-LUBRICATED! Bearing chamber is filled with proper amount of lubricant before shipment from Seal-Master factory.

4 NO HOUSING WEAR! Patented locking pin and dimple prevent rotation of outer race in housing. This eliminates housing wear . . . permits shaft alignment and positions unit for re-lubrication.

SEALMASTER Ball Bearing Units are designed and constructed to give maximum service at lowest cost. An exclusive combination of design features assure smooth-running, dependable operation. Machine designers specify SEALMASTERS to insure customer satisfaction and product integrity. Write for a copy of Catalog 845 for your files . . . it gives the complete SEALMASTER story.

Request Catalog 845 . . . It gives dimensions and load ratings for pillow blocks, flange units, take-up units, cartridge units and flange-cartridge units.

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of matched metal dies. In any article, when treating a subject such as this, we are forced to leave out a great deal of information. This article certainly was no exception and to get it into the space we had available, we simply had to cut drastically. Perhaps the next time we tackle this subject, we can include more information on this particular aspect.

Where Can I Get It?

Calcium for Battery Grids

To the Editor:

I was very interested to see under your "Highlights" section of volume 22, No. 3, March 1951, reference under "Components" to the use of calcium as a hardening agent in storage battery grids. This reference was at the top of page 7.

I am wondering if you have any further information in connection with this matter that you could send us. We manufacture storage batteries at one of our Works and we are very interested in the general subject of dry storing of batteries. —J. V. DANIEL
Crompton Parkinson Limited
London

Ed—Further information regarding the item Shelf Life mentioned in the March Highlights section may be obtained from Hugh Thomas, Bell Laboratories, Murray Hill, New Jersey.

Abrasion Resistant Paint

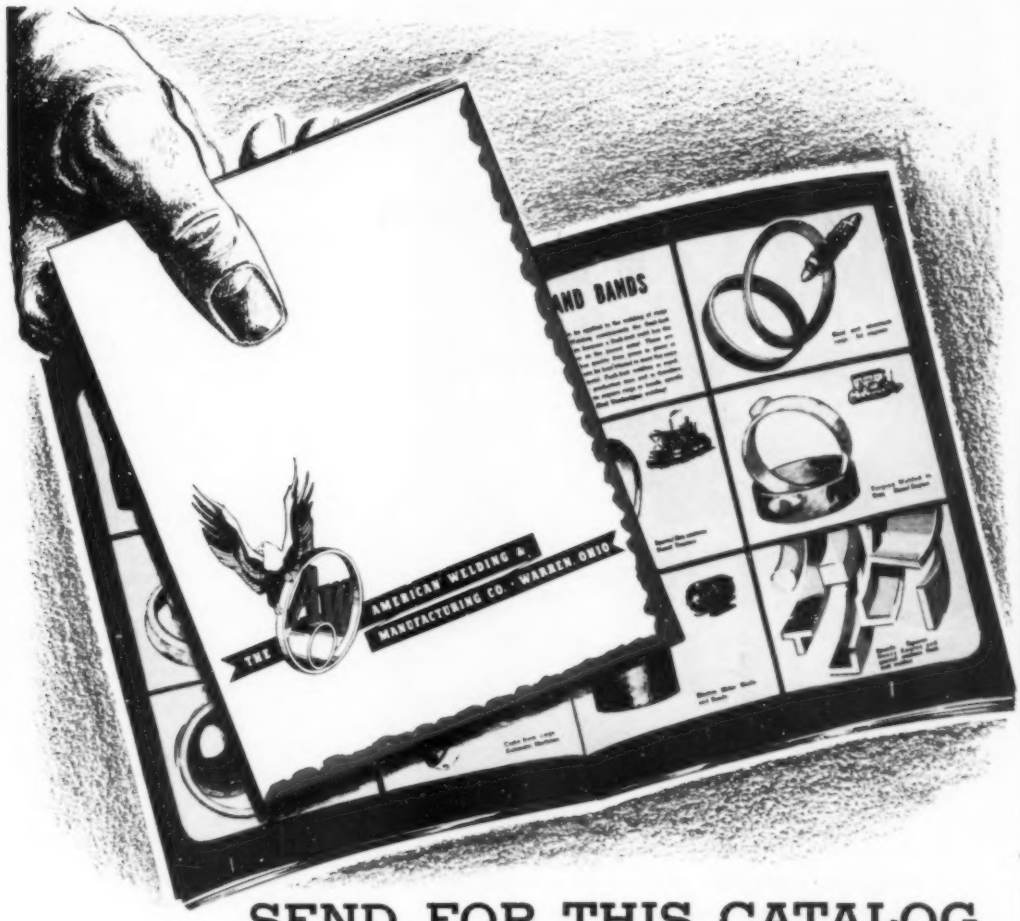
To the Editor:

We have a problem in finishing and I would appreciate any information you may have, or can have directed to me, relative to the solution of this problem.

We have manufacturers of a cordless drapery traverse. The traverse is made through ¾ in. carbon steel welded tubing, a wishbone carrier travels on this tubing by means of two plastic balls inserted in the carrier. We are seeking a bronze finish, or something acceptable to the decorating trade, which would resist the abrasion caused by the plastic balls riding on the revolving tubing.

Up to date we have used a zinc chromate base and vinyl paint. This is not entirely satisfactory because of lack of abrasion qualities and, also, it is rather an expensive procedure.

If there is available a finish that re-



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The wide scope of fabrication-by-welding of components and finished parts produced by American Welding is covered in this catalog. We have the "know-how" and the "know-why" because we've been at it for over thirty years. Let us send you a copy — it may lead to definite savings in your present and future products.

Pictorially illustrates American Welding's research, engineering, and production facilities available to manufacturers whose products lend themselves to any welding procedure.

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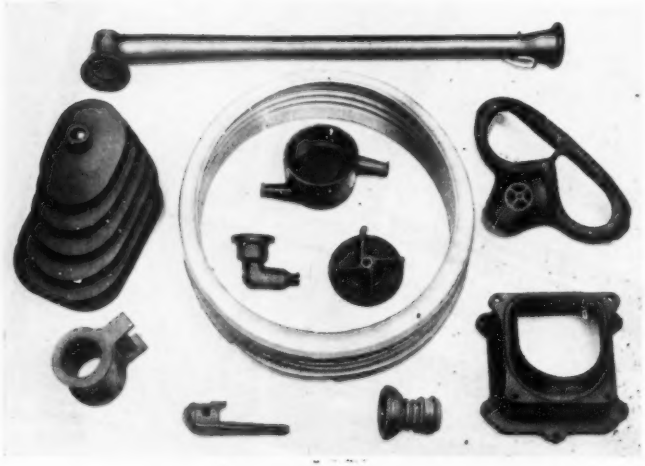
Acushnet

finds the answer to unusual Rubber problems



Intensive specialized research in Acushnet laboratories enables us to develop and furnish stocks of unusual properties and characteristics which make possible the use of rubber in applications where it has not been considered previously.

Supplementing the skill of our compounders are Acushnet's extensive quality controlled production facilities that assure precision molding of natural and synthetic rubber parts to the most exacting specifications. All Acushnet products are made on order, none are stocked.

Acushnet
PROCESS COMPANY
New Bedford, Mass., U. S. A.

Send for Rubber Handbook on your company letterhead

Address all communications to 768 Belleville Ave., New Bedford, Mass.

quires one degreasing process plus a spray process, and which would be acceptable in color and abrasion resistance, we would find that an answer to our problem.

We will appreciate any information or reference you may give us along these lines. B. N. CANTOR
Bradley Cordless Traverse Co.

Ed—Obviously, you are looking for an organic finish for your carbon steel welded tubing or at least something that can be brushed or sprayed on. I judge from your letter that you do not have the equipment for plating and that such a process would be impractical for you.

My suggestion would be that you contact one of the leading paint manufacturers in this area or drop a line to Mr. Louis Fisher, Director of Public Relations at the National Paint, Varnish and Lacquer Association, Inc., 1500 Rhode Island Avenue, Washington 5, D. C.

Gas Turbine Generator Sets

To the Editor:

We are interested in a direct gas 1000 HP turbine generator set and understand the Bovarie Co., Switzerland and Allis-Chalmers are producing successful machines.

Please advise if you can help us in regard to this. G. BODE
Bode Industrial Filter Co.

Ed—You are correct in your statement that the Brown-Bovarie Company in Switzerland and the Allis-Chalmers Manufacturing Company in Milwaukee are making gas turbine-generator sets. My understanding is that these are available in different capacities.

The General Electric Company also has been active in this field as has the Westinghouse Electric Corporation. If you are interested in further details, I would suggest that you write directly to the following people at these companies:

Mr. J. S. Smith
General Electric Co.
Apparatus Div.
Schenectady 5, New York

Mr. C. W. Kalbfus
Elliott Company
Jeannette, Pa.

Mr. Jerry Quinn
Allis-Chalmers Mfg. Co.
Milwaukee, Wis.

Mr. Campbell
Chief Engineer
Steam Turbine Division
Westinghouse Electric Corp.
So. Philadelphia, Pa.

NEW BOOKS

The Selection and Hardening Of Tool Steels

L. H. SEABRIGHT, *Research Engineer, Vulcan Stamping and Manufacturing Co.* 265 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co.,* 330 *West* 42*nd St., New York* 18, *N. Y.* $5.

This book is a systematic guide to the selection of tool steels, giving 960 analyses of steels arranged in terms of their toughness and wear resistance. Classifying all standard tool steels produced by companies in the United States and Canada into logical groups based on their properties and performance, it gives those concerned with the performance of tool steels a quick, easy method for finding the steel that is practically tailor-made for their job requirements.

Emphasizing the relationship between steels as they are actually used in industry, this book classifies tool steels, first, into 12 main groups, then into 40 subgroups or "types" in which the group members are interrelated in terms of their properties, and average hardening and tempering speeds.

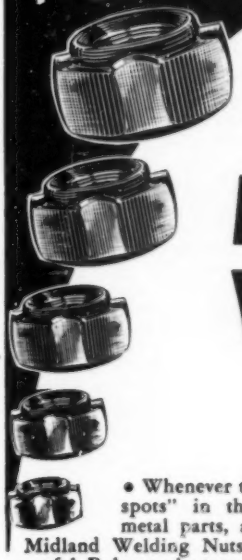
An introductory section in each group not only permits singling out the steel with the properties needed, but also getting a general line on all the steels in the group. For each of the subgroups, the book presents complete data on heat-treating and tempering, as well as a technical discussion of the effect minor variations in composition have on the properties of the steel concerned. Included is information on such heat-treating developments as martempering and salt-bath quenching.

ASTM Standards on Copper And Copper Alloys

Sponsored by ASTM Committee B-5 on copper and copper alloys, cast and wrought. 542 *pages,* 6 x 9½ *in. Published by American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.* $4.35 *heavy paper cover:* $5.00 *cloth cover.*

This edition brings together the 108 ASTM Standards pertaining to copper and copper-base alloy products. These standards represent the most up-to-date thoughts and practices and are recommended for industry usage because of substantial agreement of the various groups represented on ASTM technical

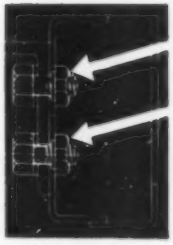
SAVE TIME in the Assembly of Metal Parts



Simplify Attachment with MIDLAND WELDING NUTS

• Whenever there are "blind spots" in the assembly of metal parts, as shown here, Midland Welding Nuts are especially useful. Bolts can be turned into Midland Nuts, without needing any device to hold the nuts from turning. Their use helps to speed production.

Investigate! Midland Welding Nuts may be the answer to some of your assembly problems.



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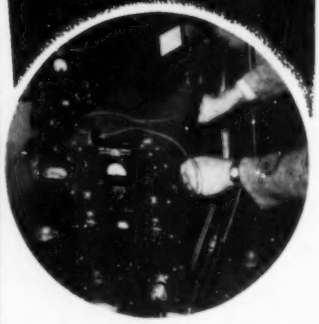
6660 Mt. Elliott Avenue • Detroit 11, Mich.
Export Department: 38 Pearl St., New York, N. Y.

World's Largest Manufacturer of AUTOMOBILE and TRUCK FRAMES

Air and Vacuum POWER BRAKES

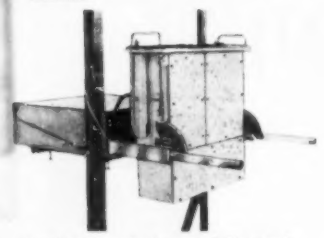
Air and Electro-Pneumatic DOOR CONTROLS

GRANT
ELECTRONIC
SLIDES
SIMPLIFY
SERVICING



The Dumont Telecruiser, a mobile TV station, features Grant Electronic Slides as a component part. Picture shows synchronizing generator and supply units which are mounted on Grant Slides. These units slide out for simplified servicing.

GRANT SLIDES ENABLE OPERATING PARTS OF UNIT TO BE ACCESSIBLE FOR MAINTENANCE.



Leading manufacturers of Electronic equipment as well as many government agencies have specified and successfully used GRANT SLIDES for many years.

Outstanding Features:

- Continuous ball bearing action
- Accurately fitted – no chassis rattle
- Pivoting and locking devices
- For loads from 25 to 2000 lbs.
- Time and manpower savings

Write Electronics Engineering Division for Complete Catalogue

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committees. Included is a section with 20 specifications on copper, copper alloys, and copper-covered steel wire, rods, bars, and stranded conductors for electrical purposes; and following this is a group of 13 specifications covering various non-ferrous metals such as slab zinc, nickel, silicon copper, lead, and others.

Also included in the compilation are test methods covering expansion, resistivity, tension, micrographs, hardness, sampling, and grain size evaluations. There are two recommended practices: Preparing tension test specimens for copper-base alloys for sand castings; and designating significant places in specified limiting values.

ASTM Standards on Petroleum Products and Lubricants

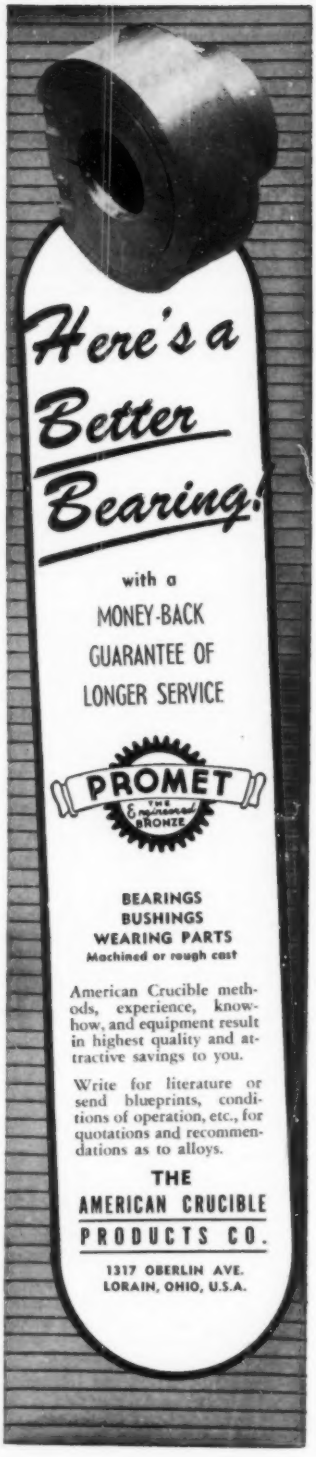
Prepared by A.S.T.M. Committee D-2 on petroleum products and lubricants. 780 pages, 6 x 9 in. Published by American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. Heavy paper cover, $5.50; cloth cover, $6.15.

This compilation brings together in compact form, most of the A.S.T.M. standards, test methods, and specifications widely used in this field. Tests for knock rating of engine fuels are not included in this compilation.

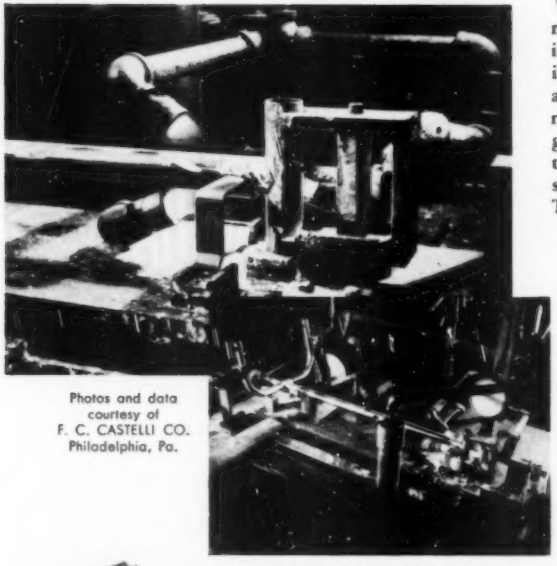
This edition gives in their latest form 125 A.S.T.M. standards, including 112 test methods; 8 specifications; 3 lists of definitions relating to petroleum, specific gravity, and rheological properties of matter; 2 tentative recommended practices for the purchase of uninhibited mineral oil for use in transformers and in oil circuit breakers, and for designating significant places in specified limiting values.

Widely used standards in this compilation cover the following broad classifications of petroleum products: Crude petroleum, motor and aviation fuels, light hydrocarbons, tractor and diesel fuels, hydrocarbon liquids, distillate burner fuels, kerosene and illuminating oils, lubricating oils, turbine oils, electrical insulating oils, plant spray oils, petroleum sulfonates, greases, petrolatums and paraffine waxes.

New material includes tentative test methods for: Askarels; boiling point range of polymerization-grade butadiene; carbonyl content of butadiene; factors and tables for volume correction and specific gravity conversion of liquefied petroleum gases; phosphorus in lubricating oils, lubricating oil additives, and their concen-



For fast production of strong tubular assemblies braze with EASY-FLO



Photos and data courtesy of F. C. CASTELLI CO. Philadelphia, Pa.

When it comes to making tubular assemblies, there's no simpler, faster, more economical way than brazing with EASY-FLO. For this amazingly free-flowing, fast-penetrating, low-temperature silver brazing alloy just naturally makes joints stronger than the metals joined. And as for fast production, you can get it as easy as ABC with EASY-FLO. All you have to do is—use a fast heating method and work out a simple set-up that speeds handling. The Castelli Toy Tractor frame job shown is a typical example.

THEY BRAZE 116 FRAMES AN HOUR THIS EASY WAY

Frames are made of 3 pieces of heavy gauge steel tubing and a bracket, all joined with EASY-FLO. Pieces are assembled in a holding fixture (see left) with a half-ring of 1/16″ alloy wire preplaced inside each end of the long tube, and a piece of 1/16″ wire along each side of the tube at the bracket. All joints are brazed simultaneously in 45 seconds. There are two brazing tables. One operator does all parts cleaning, fluxing and inserting of alloy. At each table, one assembles and loads and one supervises the brazing under the fixed gas-air burners. With just ordinary unskilled labor a production of 116 frames is readily maintained.

REMEMBER—Handy & Harman brazing experts are always ready to help you work out production set-ups without obligation. Just call or write.

GET THE WHOLE STORY IN BULLETIN 20

This bulletin makes clear why strength, speed and economy are inherent in EASY-FLO brazing. It also, is packed with information on joint design and fast heating and production methods. The many pictures too, are full of useful ideas. Write for a copy today.

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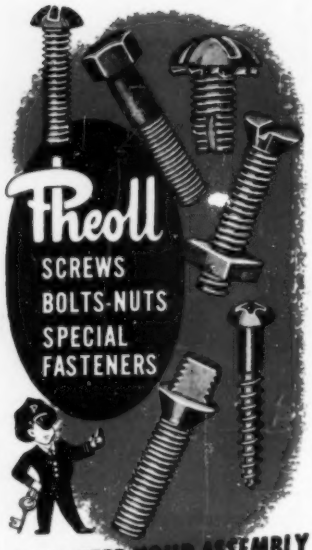

WILL KEEP YOUR ASSEMBLY LINES AT PEAK CAPACITY

Whatever you manufacture or assemble, you can speed production and improve your product by using Pheoll screws, bolts and nuts. These industrial fasteners drive easy and straight, and will not bind because threads are accurately rolled or machined. Precision-made screw and bolt heads, slots and head recesses prevent wrench and driver slippage. Count, too, the added bonus you receive by using fasteners that improve product appearance.

An interesting story on standard and special industrial fasteners and their profitable applications to your needs may be obtained from experienced Pheoll engineers. Ask these men to recommend screws, bolts and nuts that will increase your overall profits on assembly line work.

these Pheoll products prevent production lag

Tapping Screws • Cap Screws • Sems • Phillips Recessed Head Screws and Bolts • Machine Screws • Special Fasteners • Thread Cutting Screws

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trates; apparent viscosity of lubricating greases; acidity of residue from distillation of gasoline and petroleum solvents; water tolerance of aircraft fuels; analysis of 60 octane number isooctane normal heptane A.S.T.M. knock test reference fuel blends by infrared spectrophotometry; 1,3-butadiene in C_4 hydrocarbon mixtures by ultraviolet spectrophotometry; heptane number, kauri-butanol value, and nitro-cellulose diluting power of hydrocarbon solvents.

Survey of Modern Electronics

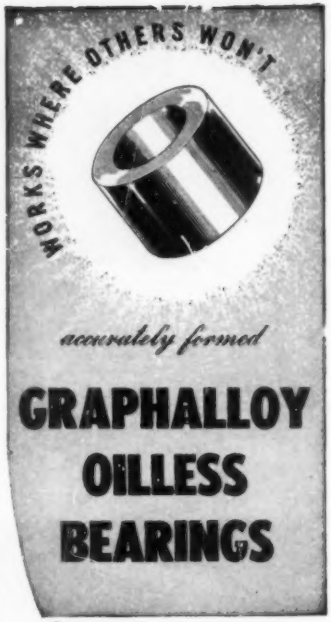
PAUL G. ANDRES, *Associate Professor of Electrical Engineering, Illinois Institute of Technology.* 522 *pages,* 6 x 9 *in. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., N. Y.* 16, *N. Y.* $5.75.

This book is intended to be a textbook for a short course in electronics. It is based on lecture and classroom notes from a condensed one-semester and a detailed two-semester course given to mechanical, chemical, and industrial engineering students to familiarize them with the basic principles of construction, operation, and application of electron tubes. It demonstrates the vital importance of electronics in nearly all branches of science and engineering.

It is assumed that the student has a knowledge of elementary electrical engineering. However, students who have completed courses in physics, d-c fundamentals and a-c fundamentals should have little difficulty with the subject. In making a representative survey of electronics the emphasis, of necessity, has been placed on a descriptive, rather than on a mathematical, treatment. Depending on the time available for the course and on the previous training of the students, the more elementary material, or the more elaborate electron-tube applications, may be omitted or curtailed without loss of continuity.

The required electrical engineering fundamentals are reviewed in many cases before discussing the electronic devices and circuits on which they are based. This approach fixes these principles more firmly in the student's mind so that they will be of practical aid to him in the future. The description of nearly every tube is followed immediately by one or more practical applications. Many of these give detailed numerical data; they help the student to obtain more definite concepts of the equipment.

Specific applications are selected to arouse and maintain reader interest and indicate some of the capabilities



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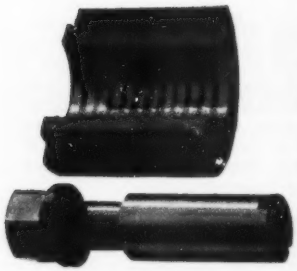

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Availability of Neoprene Bushings on Ajax Flexible Couplings is an aid to men in chemical, petroleum and other processing industries.

The use of Neoprene Bushings combines the advantages of Ajax resilient, yet positive drive with the chemical resisting characteristics of Neoprene.

Design engineers have learned to automatically think of Ajax Couplings as the standard. Their 30-year performance record is proof of their ability to safeguard bearings, gears, armatures, impellers and other costly working parts.

Ajax engineers, both in the factory and in the field, welcome the opportunity to work hand-in-hand with the men responsible for design and installation of direct-connected machines. Ajax Flexible Couplings are available in standard, bolt-on, brake drum and other types to fit most applications. Write for Bulletin 48.

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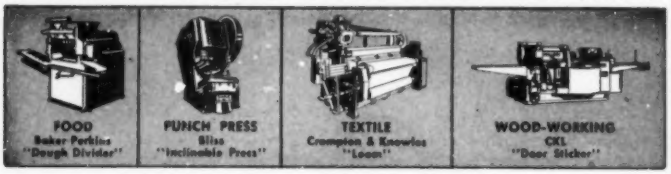
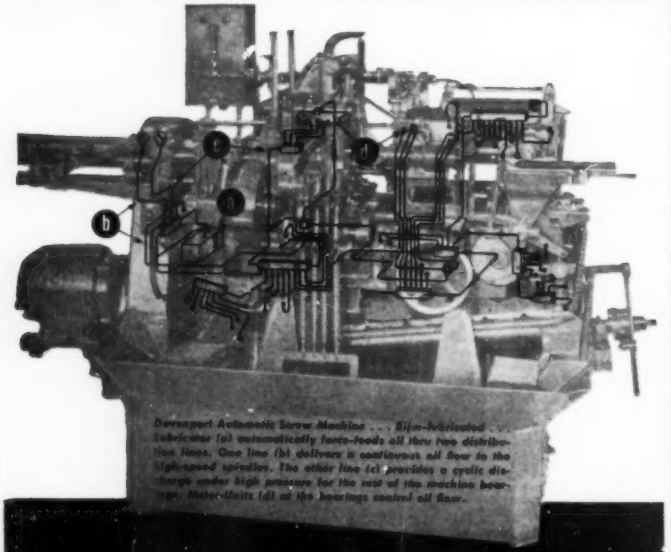
LEADING MANUFACTURERS BUILD IN THE BIJUR SYSTEM



automatic lubrication



Davenport Automatic Screw Machine . . . Bijur-fabricated . . . lubricator (a) automatically force-feeds oil thru two distribution lines. One line (b) delivers a continuous oil flow to the high-speed spindles. The other line (c) provides a cyclic discharge under high pressure for the rest of the machine bearings. Meter-Units (d) at the bearings control oil flow.

boosts production and cuts maintenance

Designing an automatic lubricating system into a machine doubles your prospects for user satisfaction.

First, maintenance time is converted into more time for production. A Bijur-lubricated machine oils itself during operation, doing away with wasteful down-time for lubrication.

Next, maintenance costs are cut as effective bearing life is lengthened. The Bijur system provides positive Meter-Unit control of oil flow *at the bearings*, considerably reducing bearing wear.

When you design that new machine, call on the Bijur engineer. Meanwhile, for further information write for "The Travels of Modern Lubrication."

389

BIJUR LUBRICATING CORPORATION

ROCHELLE PARK, NEW JERSEY

of electronics. Numerous halftones are provided to give the student a general idea of the physical size, shape, and utilization of electronic equipment. The final chapters review salient applications of electronics in instrumentation, communication, control, and heating. They offer practice in the reading of circuit diagrams.

Frequently circuits are encountered that show interconnection of tube electrodes; for example, a triode may be connected and used as a diode. Tubes are sometimes connected in this fashion in order to obtain desirable characteristics. The student should be acquainted with this practice. General references in the appendix, and specific references and problems located at the end of each chapter, are included to provide opportunity for additional study. The book should afford an opportunity, outside the classroom, for engineers and technical men who come in contact with electronic equipment to acquaint themselves with the basic principles af the subject.

Industrial and Safety Problems Of Nuclear Technology

MORRIS H. SHAMOS *and* SIDNEY G. ROTH, *Editors*. 368 *pages*, 6½ x 8 *in. Published by Harper & Brothers, 49 East 33rd St., New York* 16, *N. Y.* $4.

An outgrowth of a conference held at New York University in January, 1950, on Industrial and Safety Problems of Nuclear Technology, this book contains all the lectures but one that were presented at this forum. It is the hope of the editors that this volume will contribute to a better understanding of the vast potential of nuclear technology and to further efforts to make it serve humanity's need.

The subject matter of this book is concerned with the multifold applications of atomic energy to industry, agriculture, technology, and medicine in general. Part I is devoted to details of the organization and operation of the United States Atomic Energy Commission. Two lectures in this part, "Contracts with the United States Atomic Energy Commission", and "Patents and Inventions Under Contracts of the Atomic Energy Commission", are of special interest to engineers.

In Parts II and III, the fundamentals of nuclear physics, nuclear apparatus, the radiochemical laboratory, and industrial applications of radioactive isotopes are discussed with emphasis on the practical aspects of the problems.

Questions of health hazards, safety, and insurance associated with the use

It pays to use your custom molder's know-how

say makers of new portable 35mm. slide viewer

PROJECT:
Case, cover, condenser housing and lens housing for viewer.

CUSTOMER:
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MOLDER:
Plastic Molding Corporation
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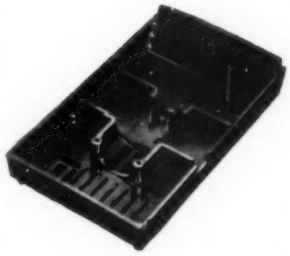
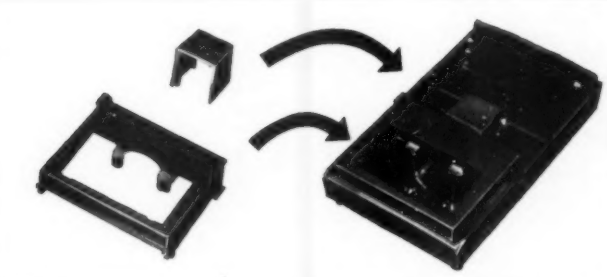
MATERIAL:
Durez black general-purpose and low-pressure phenolics.

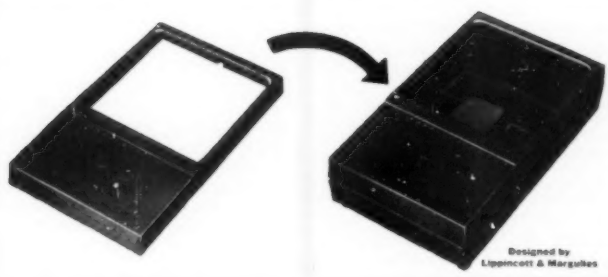
No. 27 in a Series on Plastics Skill at Work...

MOLDER USED ADAPTABILITY of Durez skillfully. Base is plunger molded low-pressure compound, which flows easily in the mold and provides high dimensional stability. One general-purpose material is used in 3 other pieces; the housings for the lens and condenser are plunger molded, and the cover is compression molded.

STRAIGHT OPEN AND SHUT dies with no cam actions or inserts are used, despite intricate shapes. Slots underneath transverse walls are obtained by locking out within the cavity itself, or by molding from 2 sides with a side lockout.







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Taking a new approach to the possibilities inherent in 35mm. color slide viewing, both as a hobby and a merchandising aid, The FR Corporation is now marketing a compact, inexpensive unit that utilizes the versatile properties of Durez phenolic plastics.

Named the Port-a-View, the new unit weighs a scant 4 lbs.—its largest parts are Durez. It is easily carried in the hand or on a shoulder strap. The dark TV-type reflex screen is six inches square—permits viewing by small groups in complete daylight. Automatic feed with storage for 72 slides helps make projection "as easy as showing a snapshot album."

The heat resistance, self-insulation, and easy moldability of Durez materials all lend themselves to the requirements of FR engineers and their designers. Almost no finishing is required—for Durez has a "built-in" glossy finish, lustrous and lasting.

When it comes to using or considering the use of plastics, your custom molder may save you much money and time. It is wise to call on him before your plans become "set." He knows the Durez materials especially well, can help you get the most from them in design and engineering. Our own 30 years of specialized experience in developing phenolic materials can always be utilized through our staff of competent field technicians.

Our monthly "Durez Plastics News" will keep you informed of industry's uses of Durez. Write, on office letterhead, to Durez Plastics & Chemicals, Inc., 2006 Walck Road, North Tonawanda, N. Y.

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Cap Screws • Set Screws • Milled Studs

Specialization at "Cleveland Cap" guarantees closer attention to accurate production, rigid inspection, and prompt shipment (as conditions permit). Our capacity is concentrated on standard Cap Screws in an unusually wide range of sizes—all popular heads; square head Set Screws, and Milled Studs. We also have capacity for producing your special design headed and threaded parts by cold extrusion. See your jobber for *standard* items; write us about your "specials."

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of radioactive materials are discussed in Part IV. This section is of particular interest to casualty and surety underwriters.

Several specific technological, safety, and insurance problems that confront industrial workers in the atomic energy field are indicated in two panel discussions.

Twenty-one leaders in the fields of industrial development, nuclear research, radiation medicine, and casualty insurance, contribute their specialized knowledge to the practical discussions of problems linked with industrial uses of fissionable material.

Theory of the Interior Ballistics of Guns

J. CORNER, *MA, Ph.D. Research Scientist, British Ministry of Supply.* 443 *pages,* 5 x 9 *in. Published by John Wiley and Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $8.

A blend of wartime and post-war research revealed weaknesses in classical theory, but Dr. Corner believes these weaknesses (for example, a tendency to oversimplify the chemical and physical processes in the gun) make it a valuable introduction to the subject.

Four types of ballistic systems are covered in this book. (1) A simple system (R.D. 38). This is very clear and particularly valuable as an introduction but empirical corrections are needed to adjust the system to real guns. (2) Two more accurate systems used in Britain. One is a streamlined version of the Charbonnier approach; the other is a simpler method giving an explicit solution. Neither needs large empirical corrections. (3) Clemmow's methods. Dr. Corner presents this system in a version suitable for practical work. (4) Methods that can be applied to newer types of guns: recoilless guns, high-low pressure guns, and tapered-bore guns.

At least one method of each type is described in sufficient detail for the reader to start using it. Dr. Corner supplies the necessary tables and explains how the different methods are related.

Although this book takes advantage of the simplicity of the classical theory, its viewpoint is one only recently developed. Advanced physical research techniques have shown the complexity of the physical and chemical processes within a gun. The result is that the approach taken to interior ballistics has changed completely. Many ideas that were thought to be basic are now known to be only empirical approximations. The present work takes into ac-

count these striking discoveries. The most modern ballistic methods are presented along with the best of the old methods. Much complicated mathematics, which filled earlier books on the subject, has been stripped away since it was based on many physical assumptions that we now know to be over simplified.

Metalworking Lubricants

E. L. H. BASTIAN, *staff engineer, Shell Oil Co.* 357 *pages*, 6 x 9 *in. Published by McGraw-Hill Book Co.*, 330 *W. 42nd St., New York* 18, *N. Y.* $6.

Main emphasis in this book is on the lubricants used in metalworking processes, but it also covers the different types and applications of lubricants for many classes of machinery.

Much practical information is presented covering the nature and formulations of metalworking lubricants, the properties affecting their performance is specific operations, their use in the plant, and procedures for maintaining efficiency of these lubricants under operating conditions. Numerous recommendation charts and tables are included.

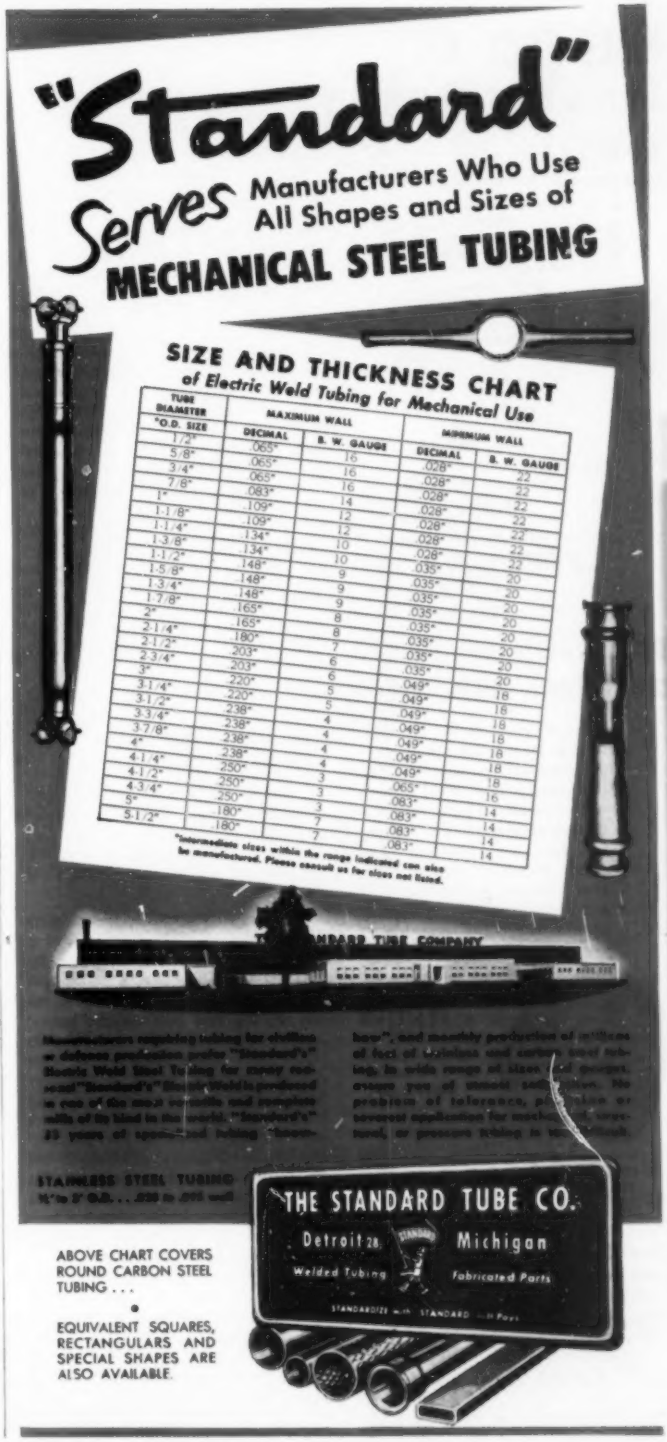
Some space is devoted to the selection and application of machine lubricants such as bearing and gear oils, greases and hydraulic fluids.

The appendixes, charts, tables and illustrations afford easy reference for the reader and amply supplement the contents. The scope of the subject matter presented is indicated by the chapter headings. These include: Types of metalworking lubricants, cutting fluids, drawing fluids and compounds, extrusion and extrusion lubricants, mold coatings, forging and forging lubricants, rolling oils, metal-coating processes, heat-treating quenching and tempering mediums, machine tool lubrication, application of lubricants, lubricant quality control, and lubricant test methods and specifications.

Plant Engineering Handbook

WILLIAM STANIAR, *Editor-in-Chief.* 6 x 9 *in.*, 2,000 *pages. Published by McGraw-Hill Book Co.*, 330 *W. 42nd St., New York* 18, *N. Y.* $15.

There is the ever increasing trend toward specialization; and now here is a handbook for plant engineers. Actually such data can be obtained from other sources. However, having it in one volume should be of considerable benefit to those engineers who are confronted with the very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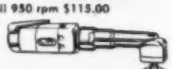

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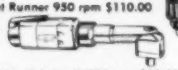

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diversified problems of organization, design and operation of industrial plants.

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In addition to an excellent section on Nomographic Charts, the subject of vibration and noise elimination are discussed. Prepared by a large and diversified group of men with broad training and experience, this book should prove quite useful for reference purposes.

Engineering Hydraulics

Edited by HUNTER ROUSE, *Professor of Fluid Mechanics and Director, Iowa Institute of Hydraulic Research, State University of Iowa, Iowa City.* 1039 *pages,* 6 x 9¾ *in. Published by John Wiley & Sons, Inc., New York, N. Y.* $15.

Although American technical literature is replete with contributions to the applied science of hydraulics, this country had still produced no comprehensive reference volume on the subject as the first half of the century neared an end. For the detailed principles of analysis required in many design problems, hydraulic engineers had recourse only to college textbooks, handbooks, and office manuals, or to such foreign works as Forchheimer's *Hydraulik,* Gibson's *Hydraulics and its Applications,* and perhaps Flamant's *Hydraulique.* Extensive treatises on hydraulic engineering had been written in the United States, but none is a thoroughgoing presentation of engineering hydraulics in its own right.

As the fourth in its series of triennial hydraulics conferences, therefore, the Iowa Institute of Hydraulic Research arranged a group of technical sessions with the specific aim of bringing such a book into existence. On the basis of preliminary discussions, the senior staff of the Institute divided the

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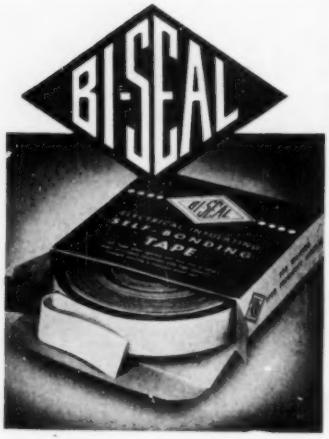

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field into thirteen interrelated subjects, and, guided by advice from its Board of Consultants, in 1947 invited authorities on the various subjects to prepare papers representing consecutive chapters of the book.

Throughout this collaborative undertaking, a concerted effort has been made to produce the type of publication originally proposed: an authoritative and up-to-date treatise on engineering hydraulics. Although the volume may well be used in many graduate courses, and although it most assuredly contains a wealth of factual information, its primary purpose is not that of either a textbook or a handbook. Neither is it intended to provide an exhaustive treatment of any particular phase of the subject. The specific aim has been to present as clear and comprehensive a treatment of every phase as either the general engineer or the specialist in another phase may require for reference.

Partial listing of chapters and authors is as follows: Fundamental Principles of Flow—Hunter Rouse, Hydraulic Similitude—J. E. Warnock, Flow Measurement—J. W. Howe, Hydrology—G. R. Williams, Steady Flow in Pipes and Conduits—V. L. Streeter, Surges and Water Hammer—J. S. McNown, Wave Motion—G. H. Keulegan and Hydraulic Machinery—James W. Daily.

Practical Design of Manufacturing Tools, Dies, And Fixtures

Prepared under supervision of ASTE *Book Committee,* EDWARD W. ERNST, *Chairman;* FRANK W. CURTIS, *Vice Chairman;* FRANK W. WILSON, *Editor-in-Chief,* 229 *pages,* 6 x 9 *in. Published by McGraw-Hill Book Co.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $2.75.

To meet the demand for specialized information on cutting-tool design and fixtures, five sections on the subject have been lifted from the "Tool Engineers Handbook" and presented intact in this compact manual.

The text covered includes cutting tools, punches and dies, jigs and fixtures, master tooling, and limited production tooling. Each topic is treated exhaustively. For example, the chapter on jigs and fixtures includes sketches and discussion of good and bad locating methods, centering devices, clamping means, universal positioning devices applicable to most machine tools, ways to minimize tool breakage, standardized jig and fixture parts, ejectors, foolproofing, etc.

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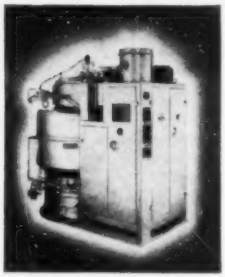

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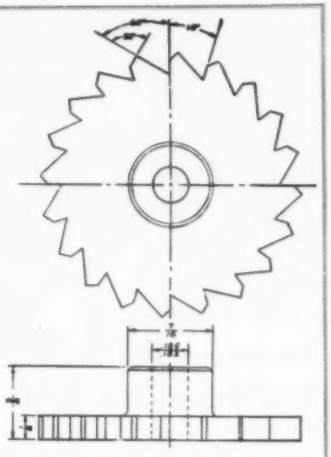

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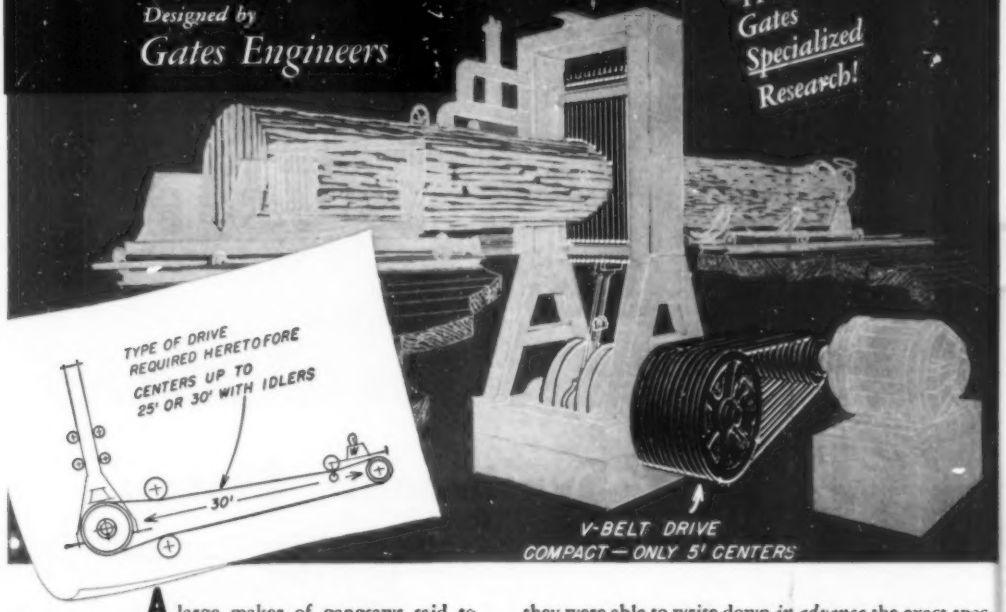

A large maker of gangsaws said to Gates Engineers, "If you can design a V-Belt drive to handle the *fluctuating load* on a gangsaw, we can discard the long and troublesome flat belt that we have always thought we had to use."

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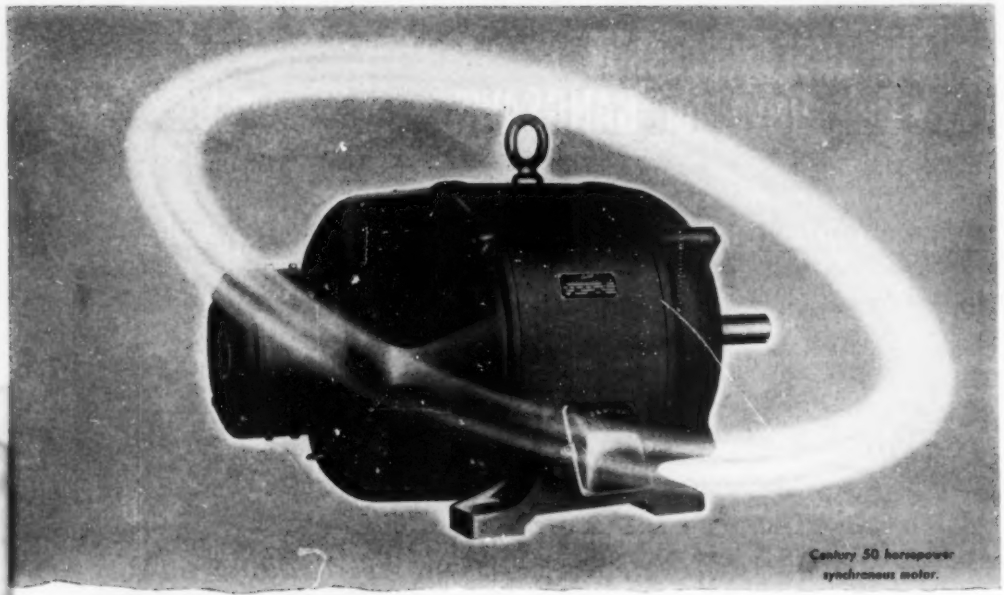

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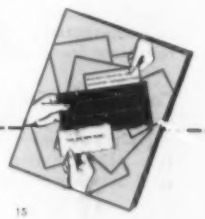

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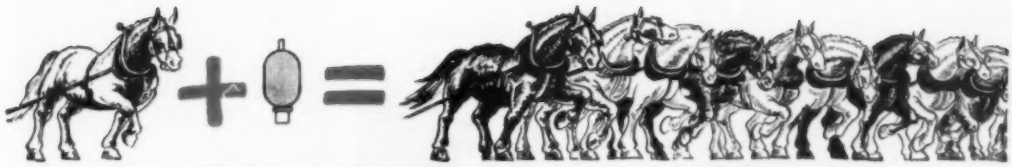

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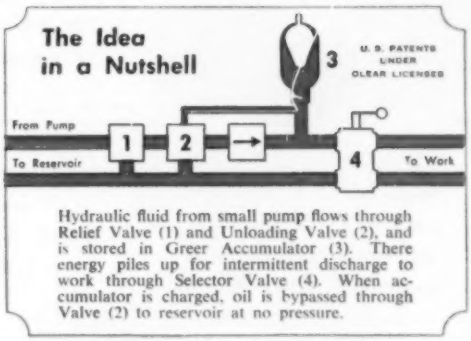
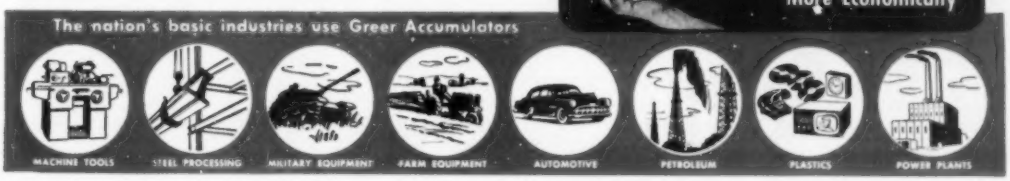


Hydraulic fluid from small pump flows through Relief Valve (1) and Unloading Valve (2), and is stored in Greer Accumulator (3). There energy piles up for intermittent discharge to work through Selector Valve (4). When accumulator is charged, oil is bypassed through Valve (2) to reservoir at no pressure.



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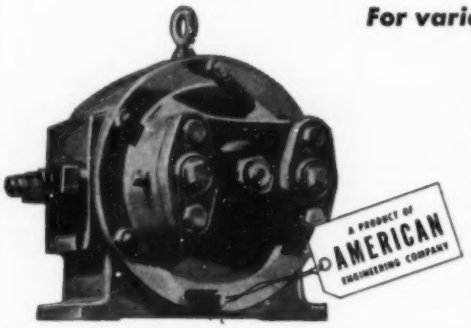

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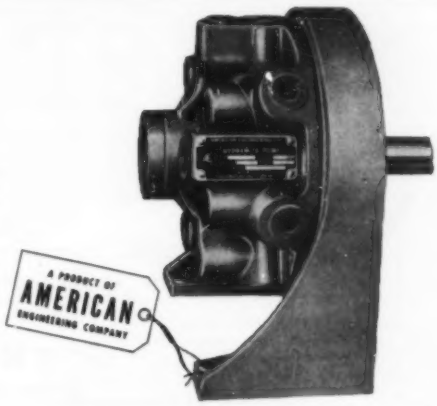

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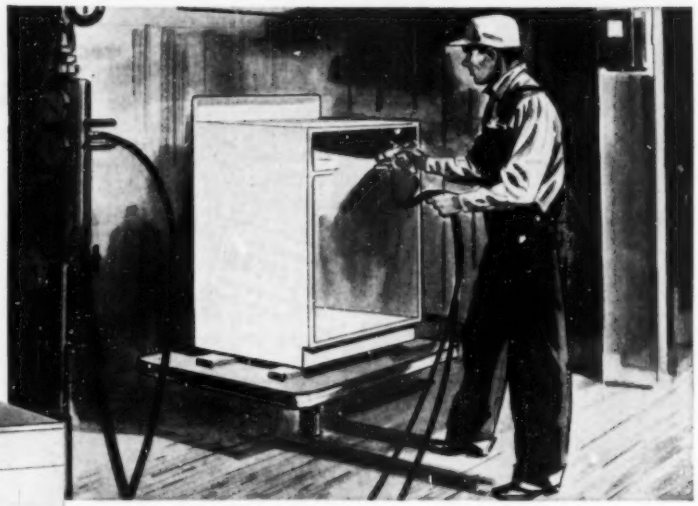

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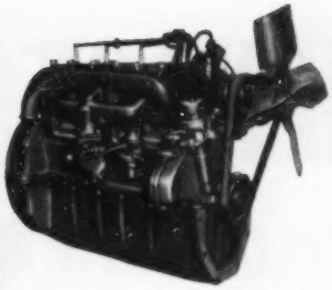

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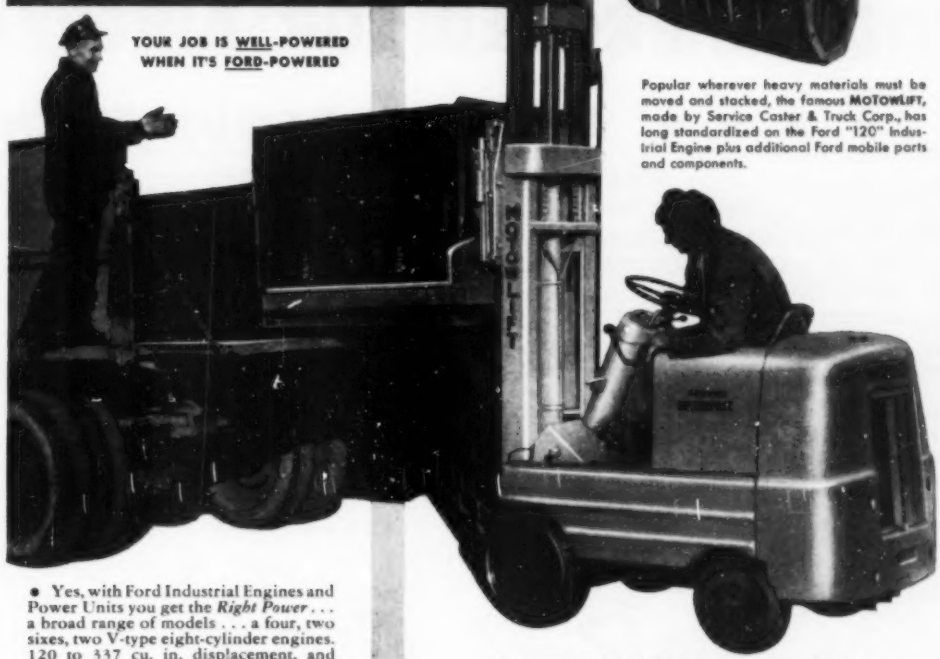

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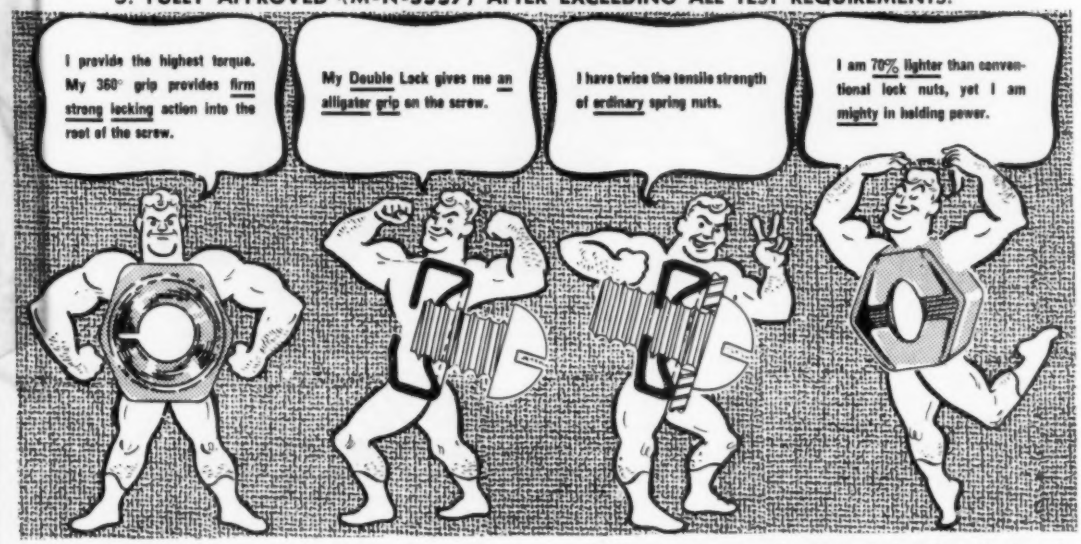
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I have twice the tensile strength of ordinary spring nuts.
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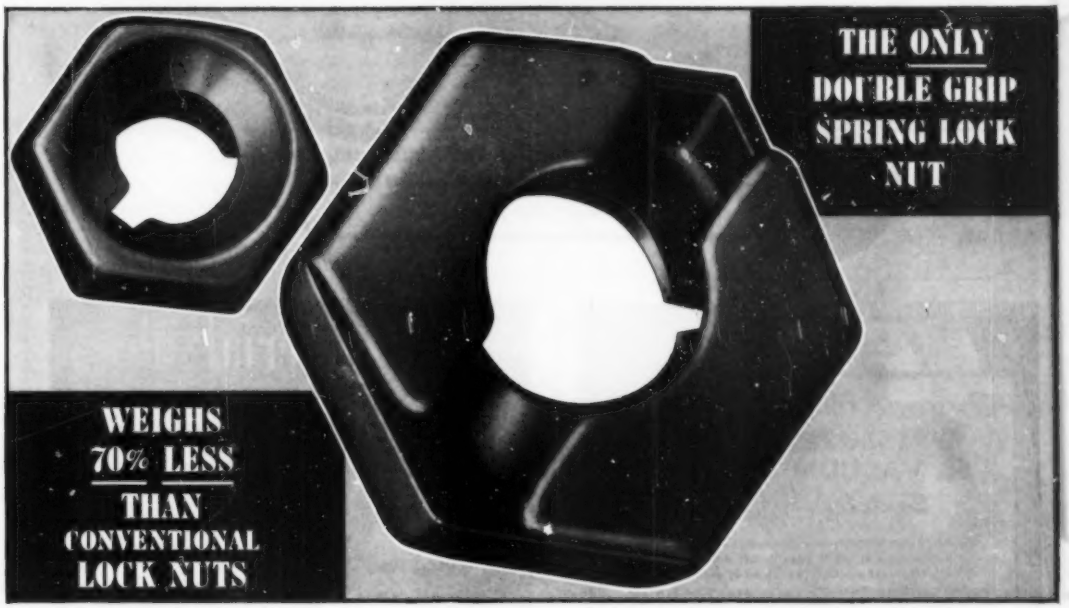
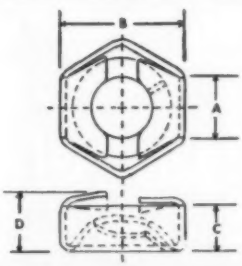
OF M-N-3337 ★ ★ ★ ★





MATERIAL SAE-1060

SCREW SIZE	PART NUMBER	A	B	C	D	MATERIAL THICKNESS T
¼-20	M 350-1	15/64	7/16	5/32	.200	.020
10-24	M 350-2	3/16	3/8	1/8	.1875	.020
10-32	M 350-3	13/64	3/8	1/8	.165	.016
8-32	M 350-4	11/64	11/32	1/8	.155	.016
6-32	M 350-5	9/64	5/16	3/32	.140	.016

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TYPE SB

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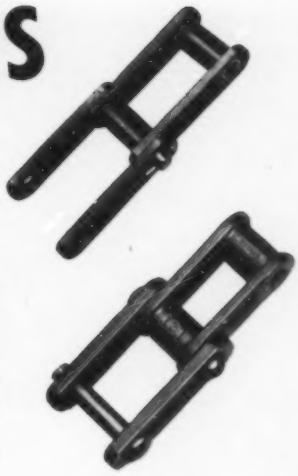

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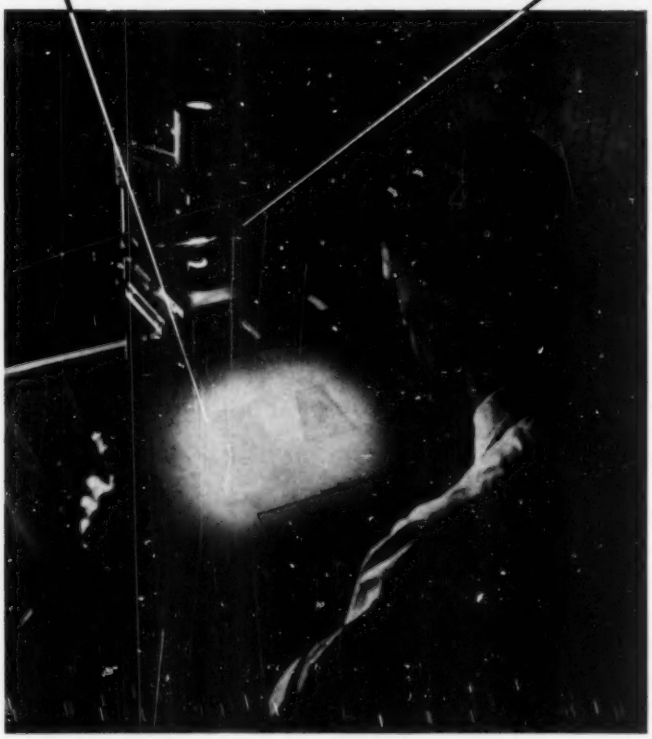

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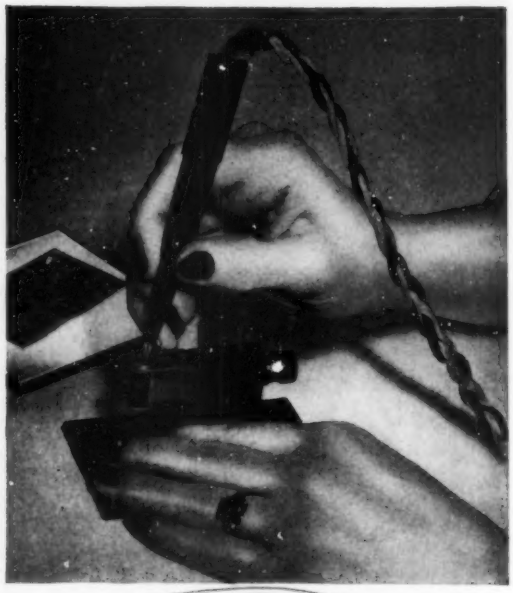
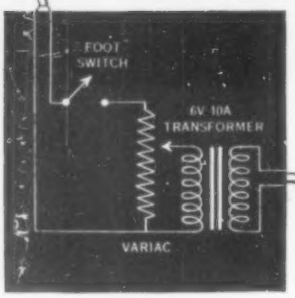
marion methods *electrify* TWEEZER SOLDERING





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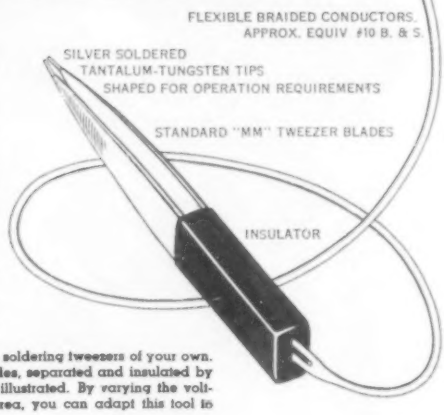
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STANDARD "MM" TWEEZER BLADES
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MARION USES THIS METHOD of Tweezer Soldering for precise hairspring soldering, positioning small metal parts in thermoplastic cements, and in other fine soldering operations. Resistance heating in the work itself and conducted heat from the tips combine to give greatly increased soldering rates on pretinned components. Because the tweezers develop little heat themselves, adjacent component damage is avoided. These tweezers permit an inexperienced worker to rapidly acquire a high degree of skill. Both positioning and soldering are combined with the handling ease of a fountain pen.

NOT FOR SALE — You can make electric soldering tweezers of your own. Those shown here have standard "MM" blades, separated and insulated by bakelite. They are assembled and wired as illustrated. By varying the voltage, the tip cross-section, and the contact area, you can adapt this tool to your specific application.

OTHER MARION METHODS — Current demands on industry by the mobilization program accentuate the importance of production methods. Electric tweezer soldering is only one of a number of methods which Marion proposes to present in the hope that some of them can help you as much as they have helped us. Marion Electrical Instrument Company, 415 Canal Street, Manchester, N. H., U. S. A.

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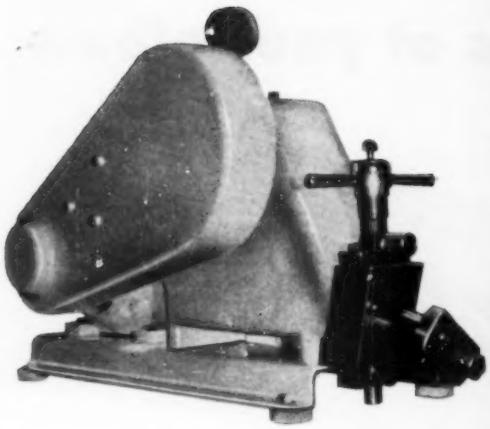

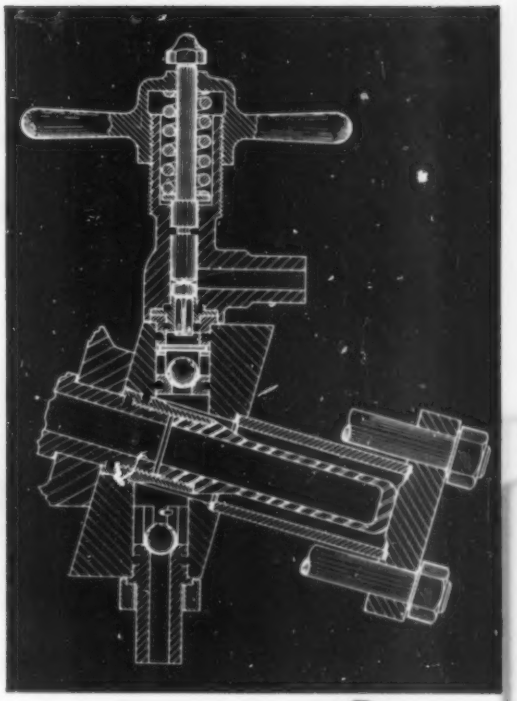

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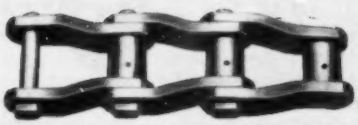

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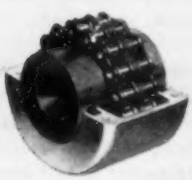

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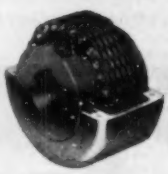

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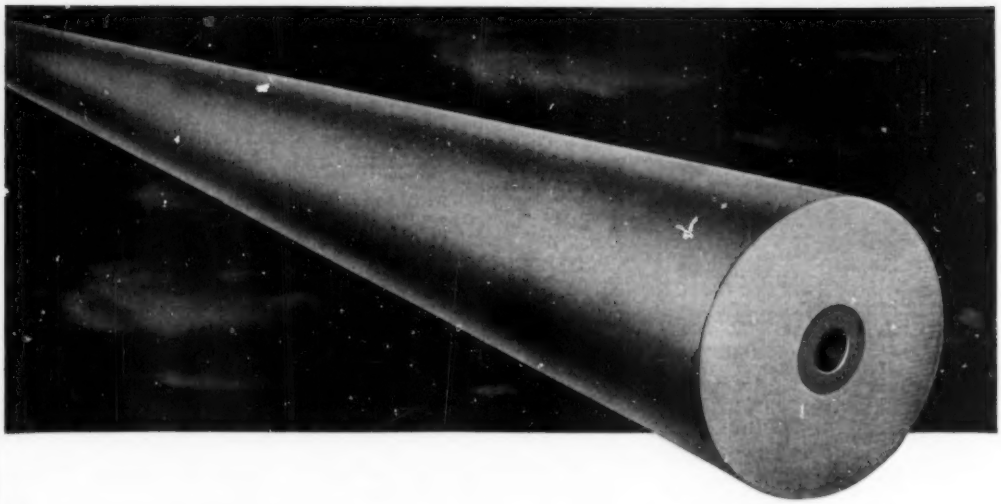

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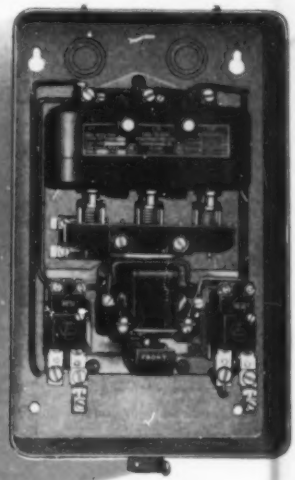

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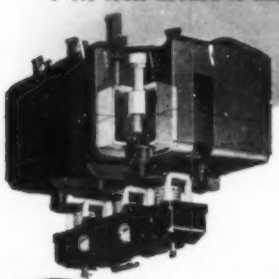

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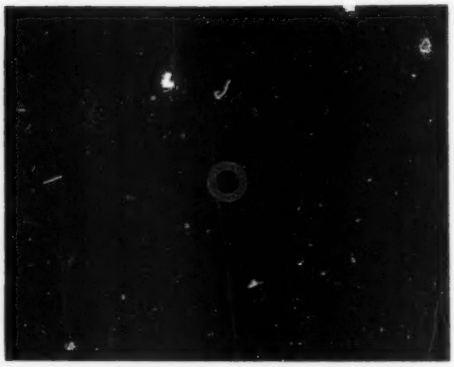

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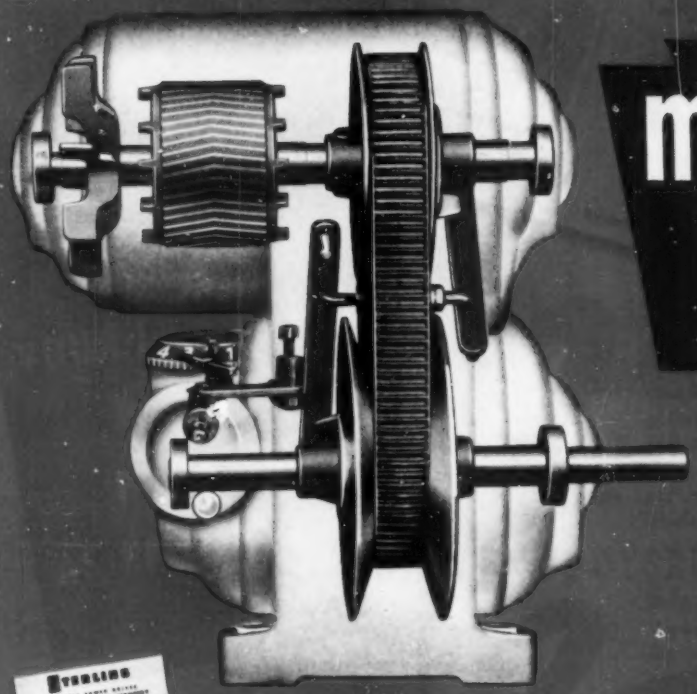

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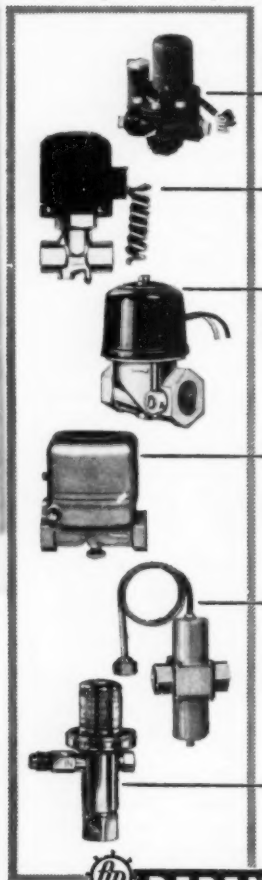

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3301 Boston's Lane
BIRMINGHAM, ALABAMA
Owen-Richards Co., Inc.
1009 2nd Ave. N.
BOSTON, MASSACHUSETTS
Chandler & Farquhar, Inc.
900 Commonwealth Ave.
BRIDGEPORT, CONNECTICUT
Hawley Hardware Co.
1120 Main St.
BROOKLYN, NEW YORK
H. L. Dickie
314-366h St.
BUFFALO, NEW YORK
Root, Neal & Co.
64 Peabody St.
CHARLOTTE, NORTH CAROLINA
Matthews-Morse Sales Co.
301 East 7th St.
CHATTANOOGA, TENNESSEE
Volunteer Bearing & Transmission Co., Inc.
2000 South Broad St.
CHICAGO, ILLINOIS
Boston Gear Works
955 W. Washington blvd.
Chgo. Pulley & Shafting Co.
23 N. Desplaines St.
Samuel Harris & Co.
114-116 N. Clinton St.
Power Trans. Equip. Co.
1245 W. Fulton St.
CINCINNATI, OHIO
Queen City Sup. Co.
Pearl & Elm Sts.
CLEVELAND, OHIO
Bearing Distributors, Inc.
2618 Carnegie Ave.
Boston Gear Works
211 St. Clair Ave., N. W.
Neo-Sherwood Sup. Co.
800 Lime Road
COLUMBUS, OHIO
Ohio Trans. Co.
666 Parsons Ave.
DALLAS, TEXAS
Geo. J. Fix Co.
2413-15 Commerce St.
DAYTON, OHIO
Klinger Oils
1041 So. Patterson Blvd.
DENVER, COLORADO
Western Belting & Packing Co.
1720-28 Wazee St.
DES MOINES, IOWA
Standard Bearings Co.
1014 Grand Ave.
DETROIT, MICHIGAN
Chas. A. Strelinger Co.
148-162 E. Larned St.
GRAND RAPIDS, MICHIGAN
Mackay Industrial Sales Co.
704 Jefferson, S. E.
GREENSBORO, NORTH CAROLINA
Trans. Supplies, Inc.
403 Walker Ave.
HAMILTON, ONTARIO
Ronald-Coventry, Ltd.
443 King St. E.
HARTFORD, CONNECTICUT
Silstar-Holden, Inc.
433 New Park Ave.
HOUSTON, TEXAS
Geo. J. Fix Co.
2703 Polk Ave.
INDIANAPOLIS, INDIANA
Vonnegut Hardware Co.
402 W. Maryland St.
JACKSONVILLE, FLORIDA
S. E. Hubbard Co.
30 W. Bay St.
KANSAS CITY, MISSOURI
Wolcott Mchy. & Sup. Co.
1219 McGee St.
KNOXVILLE, TENNESSEE
Pfeyl N. Payne Co.
410 L. Depot Ave.
LANCASTER, PENNSYLVANIA
Herr & Co., Inc.
Prince & Chestnut Sts.
LONDON, ONTARIO
Ronald-Coventry, Ltd.
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LONG ISLAND CITY, NEW YORK
L. C. Bigelow & Co., Inc.
11-06 Jackson Ave.
LOS ANGELES, CALIFORNIA
Andrews Hardware & Metal Co.
334 S. Main St.
Garrett Supply Co.
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LOUISVILLE, KENTUCKY
Industrial Equip. Co.
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MIAMI, FLORIDA
Gendes Corp.
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MILWAUKEE, WISCONSIN
Western Iron Stores Co.
319-331 East Clybourn St.
Wisconsin Bearing Co.
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1100-08 3rd Ave. S.
MONTREAL, QUEBEC
Ronald-Coventry, Ltd.
1006 Mountain St.
NEWARK, NEW JERSEY
Squier, Schilling & Stoff
419 Plane St.
NEW ORLEANS, LOUISIANA
McLellan A-C Sup. Co.
2375 Tchoupitoulas St.
NEW YORK, NEW YORK
L. C. Bigelow & Co., Inc.
280 W. 54th St.
Boston Gear Works, 480 Canal St.
Frank Tracy, Inc., 202 Centre St.
OAKLAND, CALIFORNIA
C. W. Marwedel
11th & Alice Sts.
PHILADELPHIA, PENNSYLVANIA
Boston Gear Works
Broad St. Car. of Lycoming & 16th Sts.
Lindsey, Oberholtzer & Co.
4432 Ridge Ave.
Maddock & Company
42 N. Sixth St.
PITTSBURGH, PENNSYLVANIA
Somers, Fitler & Todd Co.
313-327 Water Street
PORTLAND, OREGON
Woodbury & Co.
133 S. W. 2nd Ave.
PROVIDENCE, RHODE ISLAND
Machine Parts Corp.
271 Washington St.
QUEBEC, QUEBEC
Ronald-Coventry, Ltd.
5 Boulevard Ave.
QUINCY, MASSACHUSETTS
Boston Gear Works
14 Hayward St.
RICHMOND, VIRGINIA
Industrial Sup. Co.
15th & Franklin Sts.
ROCHESTER, NEW YORK
John M. Forster Co.
110 Mill St.
ST. LOUIS, MISSOURI
Concord-Wright Mchy. & Sup. Co.
1223-1229 N. Broadway
SAN FRANCISCO, CALIFORNIA
Boston Gear Works
123 10th St.
C. W. Marwedel
1235 Mission St.
SEATTLE, WASHINGTON
Cregan & Co.
932 First Ave. S.
SPRINGFIELD, MASSACHUSETTS
Boston Gear Works
19 Worthington St.
SYRACUSE, NEW YORK
Syracuse Sup. Co.
314 W. Fayette St.
TAMPA, FLORIDA
Southern Pump & Sup., Inc.
902 Twiggs St.
TOLEDO, OHIO
Ohio Belting & Trans. Co.
406 Orange St.
TORONTO, ONTARIO
Ronald-Coventry, Ltd.
50 Edward St.
TRENTON, NEW JERSEY
Wiley-Hughes Sup. Co.
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Ronald-Coventry, Ltd.
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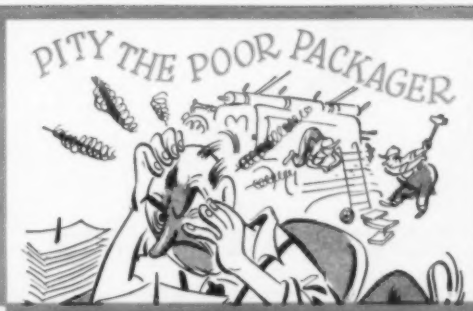
WINSTON-SALEM, NORTH CAROLINA
Easter Machinery Co.
306 E. 3rd St.
WORCESTER, MASSACHUSETTS
W. H. Steele Co.
171 Fremont St.

BOSTON Gear STOCKS ARE Near

TEN "BARGAIN PRICE" GEARS SAVED HIM $10.50 — AND COST HIM $96.00

It was a printing press drive. The five pairs of gears seen were cut and were replaced by BOSTON Spur Gears cut 20° Pressure Angle*

Cost of pulling down press and replacing gears (two men, 4 hrs. @ $2.00 per hr.)	$16.00
Down Time loss (profit and overhead) 10 reams per hr. @ $2.00 per ream	$80.00
TOTAL	$96.00



FOUR "BARGAIN PRICE" GEARS SAVED HIM $2.40 — AND COST HIM $178.00

Four inferior gears driving a packaging machine had to be replaced by BOSTON Gears.

Cost of repairing machine (one man, 8 hrs. @ $2.25 per hr.)	$18.00
Down Time loss (profit and overhead) — 8 hours production, 2000 units per hr. @ $0.01 apiece	$160.00
TOTAL	$178.00

DON'T LET *Yourself* IN FOR LOSSES LIKE THESE

***LOOK WHAT BOSTON 20° PRESSURE ANGLE GEARS SAVE YOU!**

Specify Boston 20° Pressure Angle Gears instead of the ordinary 14½° P.A. gears of identical horsepower rating and save:

21.2% in COST
23.4% in WEIGHT
16.9% in SPACE

Ask your nearby Boston Gear Distributor for Boston 20° Pressure Angle Gears.

STANDARDIZE ON STOCK BOSTON GEARS DESIGN THEM INTO YOUR EQUIPMENT ALWAYS SPECIFY THEM FOR REPLACEMENTS

Write for free copy of Boston Gear Catalog No. 55.

BOSTON Gear stocks are New

(see adjacent list of Authorized Boston Gear Distributors)

POWDERMET* PARTS

INCREASE YOUR

PRODUCTION CAPACITY

PRECISION PARTS ARE DELIVERED READY FOR ASSEMBLY WITHOUT FURTHER PROCESSING!

Gears, bearings, electronic components and small assembly parts are fabricated to your specifications and tolerances. You avoid troublesome raw material procurement problems, decrease the burden on over loaded equipment in your own plant and reduce costs at the same time. Send for this free booklet today and see how "Powdered Metal In Your Production Picture" will increase your output!

POWDERED METAL PRODUCTS CORPORATION *of America*

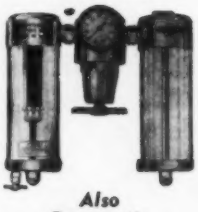
9335 West Belmont Avenue, Franklin Park, Illinois

PMP

*Trade Mark

"M-B" AUTOMATIC *Air Line* FILTER, REGULATOR and LUBRICATOR ASSEMBLY

"Sentinel of the Air Line"



Also Pneumatic Grinders

"Remember, Built-in quality remains long after first-cost disappears"

FILTER element removes solids .00039 and larger. TRANSPARENT BOWL provides visibility. REGULATOR is capable of passing large volume with an unrestricted flow and minimum amount of pressure drop. Self-bleeding, compact, simple. Machined from bar aluminum. LUBRICATOR delivers desired volume of oil. Adjustable Venturi Valve permits efficient operation on broad range of volume and pressure. Bowl can be refilled without shutting off air supply. Any of these 3 devices can be used as separate units or in any combination.

Write for Literature

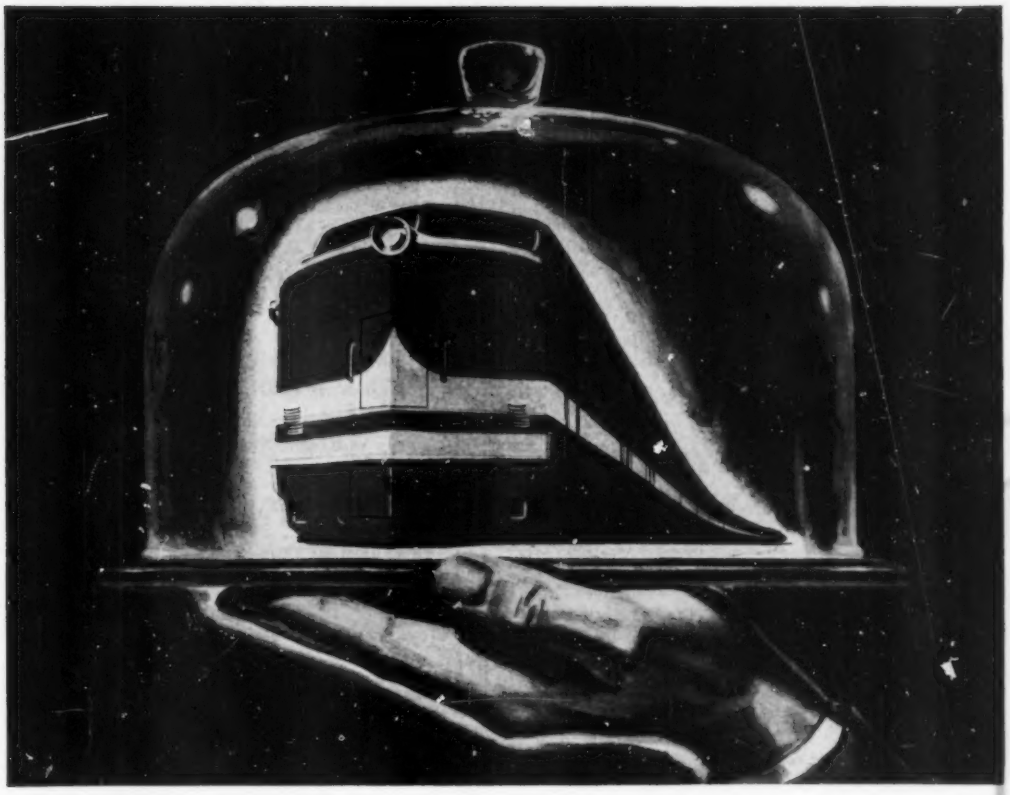
M-B PRODUCTS

46 Victor Ave.
DETROIT 3, MICHIGAN

CONTROL POWER BETTER

7 out of 10
Leading Road Grader Manufacturers Use
ROCKFORD CLUTCHES
To Insure Reliable Service Under the Difficult Working Conditions Met in Road Building Work.
Let our engineers show you how ROCKFORD CLUTCH design and construction advantages will help make your product operate more efficiently and economically under adverse conditions.
ROCKFORD CLUTCH DIVISION
BORG-WARNER
309 Catherine Street, Rockford, Illinois

ROCKFORD CLUTCHES



Under Glass...THEY'D LAST FOREVER!

If you could pack your electrical apparatus in glass, there's no telling how long it would last!

But it's service use that pays off in profits, so a prominent locomotive maker chose the next best use for the protective qualities of glass—or, more specifically, insulating materials made with Fiberglas* yarns.

Here's how he does it:

Electric traction motors that directly drive the wheels on diesel-electric engines, normally have a usable life of only 600,000 road miles. Armatures and coils insulated with organic materials break down under service use, causing costly down-time.

The solution: Coil and armature insulation made with Fiberglas glass-base materials and silicones which permit higher currents, resist heat far longer. The result: traction motor ratings increased from 700 to 835 amperes . . . braking effort upped 23% . . . locomotive rating upped 25% . . . and, most important of all, *road-mile life increased 8 times!*

This is just one example of product improvement made with Fiberglas glass-base insulations. If you make or use electrical apparatus, it will pay you to investigate Fiberglas insulating materials.

OWENS-CORNING FIBERGLAS CORPORATION, ELECTRICAL SALES DIVISION, 16 East 56th Street, New York 22, N. Y.

OWENS-CORNING FIBERGLAS

FIBERGLAS IS IN YOUR LIFE...FOR GOOD!

*Fiberglas is the trade-mark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with glass fibers.

For Drawings That Won't Get 'EDGY' With Age...

Specify Arkwright Tracing Cloth! Then you can be sure that no matter how often a master drawing is yanked out of the cabinet, it will never become ripped, or paper-frayed around the edges to spoil your work.

Arkwright Tracing Cloth is the best insurance you can get that your drawings will never go brittle, discolor or become opaque with age. Best insurance, too, that original drawings are always sharp, clean and ghost-free. Erasures on Arkwright cloth re-ink without feathering. And every roll is carefully inspected for pinholes, thick threads or imperfections of any kind.

All good reasons for you to remember: if a drawing is worth saving, put it on Arkwright Tracing Cloth. Would you like a sample? Write Arkwright Finishing Company, Providence, R. I.

ARKWRIGHT
Tracing Cloths
AMERICA'S STANDARD FOR OVER 25 YEARS

for
SPECIAL
INSULATION PROBLEMS
of
Polyethylene and *Vinyl*

. . . we offer our facilities for special compounds, special design, extrusion and fabrication. Consult:

Extruded Products Division
DEPT. PE
GERING PRODUCTS
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Pioneers in Electronic Insulation
KENILWORTH, N. J.

PRECISION DIE MADE — LOWEST POSSIBLE COST
DAYTON ROGERS MFG. CO.
Minneapolis 7, Minnesota

CURTIS *since 1919 exclusively a manufacturer of*
UNIVERSAL JOINTS
Can Save You TIME and MONEY!

14 sizes—3/8" to 4" O.D.—in stock at all times and ready for immediate sample or volume shipments.

PLUS Every facility for special specification jobs. Free engineering data and price lists on request.

- Ball type for light duty application
- Standard for heavy duty
- Lo-Friction for most exacting demands

Whatever your requirements, we invite your inquiry.

CURTIS UNIVERSAL JOINT CO., Inc.
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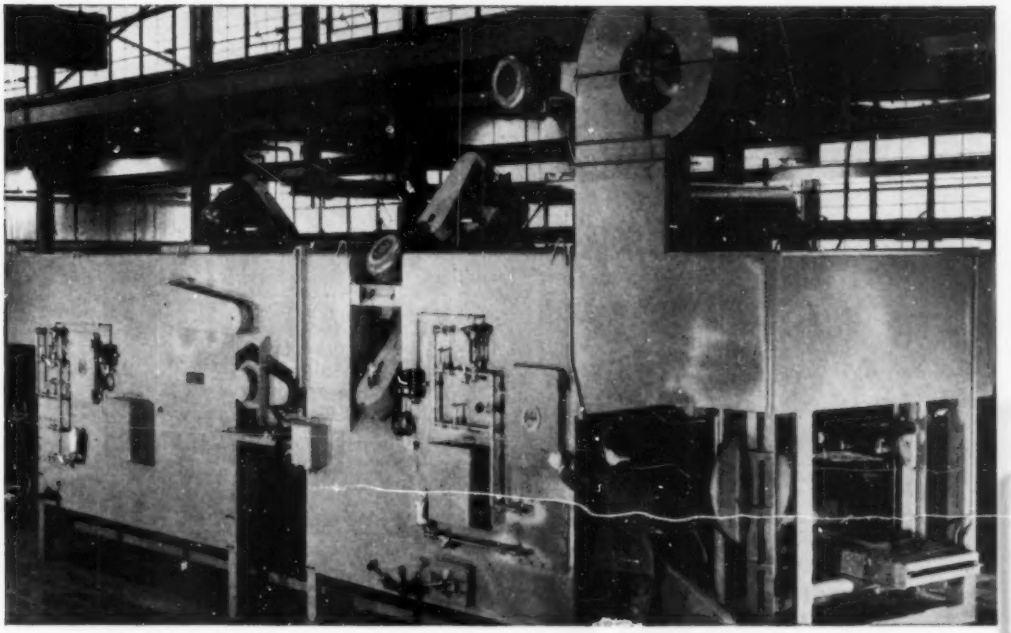
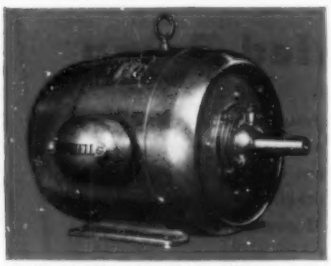
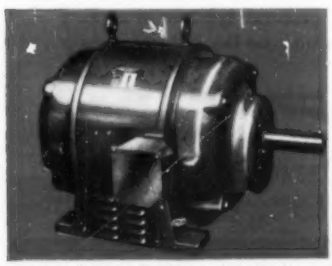


How to give a cylinder block a clean start



Howell Type K Motor. Offers constant performance in the presence of dirt, dust, fumes and moisture. Sizes 3 to 150 H.P. at 1800 R.P.M. Either vertical or horizontal mounting.



Howell Type F Motor. A high-slip, high-torque motor designed for punching and shearing operations. Sizes ½ to 200 H.P. in open frames; ½ to 125 H.P. in enclosed frames.

This new Centri-Spray washer thoroughly cleans up to 400 cylinder blocks an hour. It often runs 3 shifts a day, six days a week. A tough job for the nine Howell Industrial Motors which power it!

Four 25-H.P. motors operate the unique Centri-Spray units which envelop the rotating blocks with a powerful high-volume spray of water. A high-head centrifugal pump, equipped with a 15-H.P. motor, flushes blocks internally. All foreign matter is *completely removed*, inside and out. Four motors, from 1/3 to 20 H.P., power the automatic sludge remover, the recirculating pump, the main conveyor and the high-pressure blowoff fan.

Howell engineers worked closely with this manufacturer to provide the *right* motor for each application. As a result, this Howell-powered washer easily takes the hardest operating schedule in stride.

Highest quality motors, designed for your specific jobs, are typical of the service you get from Howell. Let us handle your electric motor needs. You'll find precision-built Howell industrial type motors a profitable investment that pays off in extra years of dependable performance.

HOWELL ELECTRIC MOTORS COMPANY

Howell, Michigan

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Precision-built industrial motors since 1915

Found:

The 2% that cured a Pickled Pump

How years of N-B-M Metallurgical experience paid off by solving a severe problem of corrosion

When a vinegar producer suddenly starts having frequent pump failures due to extreme impeller corrosion, it's pretty evident that something unusual is going on . . . particularly when the same pump had been used successfully for years. The pump manufacturer sent an engineer to the installation . . . and found that *concentrated* vinegar was being pumped, instead of *diluted* vinegar as before. Impellers in some cases were lasting only 1 week.

The pump manufacturer came to us with the facts—and our Metallurgical Department was immediately put to work on the problem.

Result? **In a matter of days, impellers of a new alloy were on their way with a slight but important alloy change . . . the addition of 2% nickel. These impellers now last 18 months to 2 years—longer than they ever had before!**

We're proud of examples like this . . . because they show how effectively our facilities for Research and Engineering — combined with 75 years of practical application experience—make money-saving solutions to problems on . . .

Non-Ferrous Bearings and Castings—
As-Cast or Machined

Bronze Bars—
As-Cast or Machined; Cored, Solid, Hexagon

Babbitt Metals—
For every type of bearing service

AMERICAN Brake Shoe COMPANY

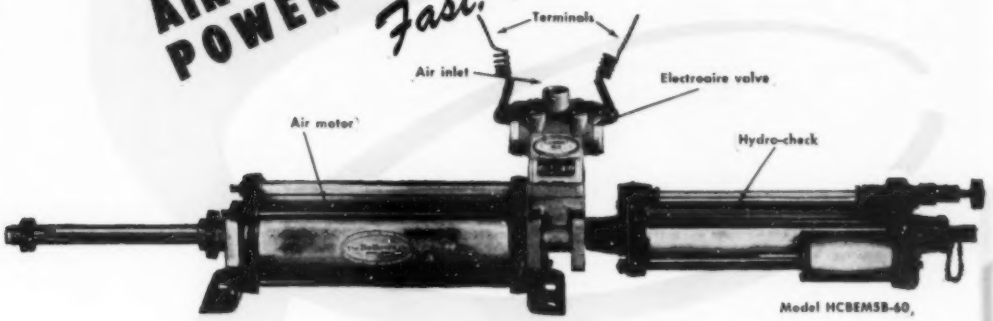
NATIONAL BEARING DIVISION
4932 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST. LOUIS, MO. • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

Built-in Controls Make This

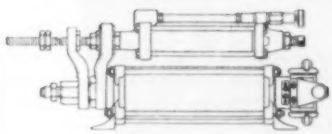
AIR CYLINDER POWER UNIT

Fast, Smooth, Compact



TWO MOUNTING STYLES

Model HCBEM Air Motor and Hydro-Check is available arranged in tandem, as shown above, or in parallel, as sketched below:



Five bore sizes: 1¼", 1¾", 2½", 3⅛" and 4½". Stroke lengths up to 18" or more. Combination units of Air Motor and Hydro-Check are also made equipped with the standard Bellows manually operated valve; and of course, Air Motors and Hydro-Checks are available as separate units.

You get the smooth piston travel characteristic of hydraulic operation plus the fast flexibility of air power from the Bellows Air Motor and Hydro-Check, combined in a single unit.

This compact power unit has the built-in ELECTRO-AIRE* directional valve; electrically controlled, but *air-powered*. The valve operates on 8 volts, so you can use simple low voltage wiring. No electrical hazard to operator or machine. Place your controls where you wish. The piston rod responds instantly, without lag or delay.

This power unit is fast. The valve can make as many as 2200 movements an hour, all day long, without overheating. Built-in speed controls (one for the power stroke, one for the retract) let you adjust piston rod speed to your own needs.

But the Hydro-Check is the control element that makes this power unit so radically different. The Hydro-Check flattens out the bounce or chatter that occurs as a result of the natural compressibility of air. The air cylinder piston movement becomes miraculously smooth. You have the smoothness of hydraulic operation plus the advantage of air's speed and flexibility. You can set the Hydro-Check to take over control at any point; so you can have rapid advance and rapid return, yet have full control over the feeding stroke.

All in all you just can't beat the combination of Bellows Air Motor and Hydro-Check for fast, smooth, accurately controlled air cylinder power.

* TM Reg. Patent Pending

Write

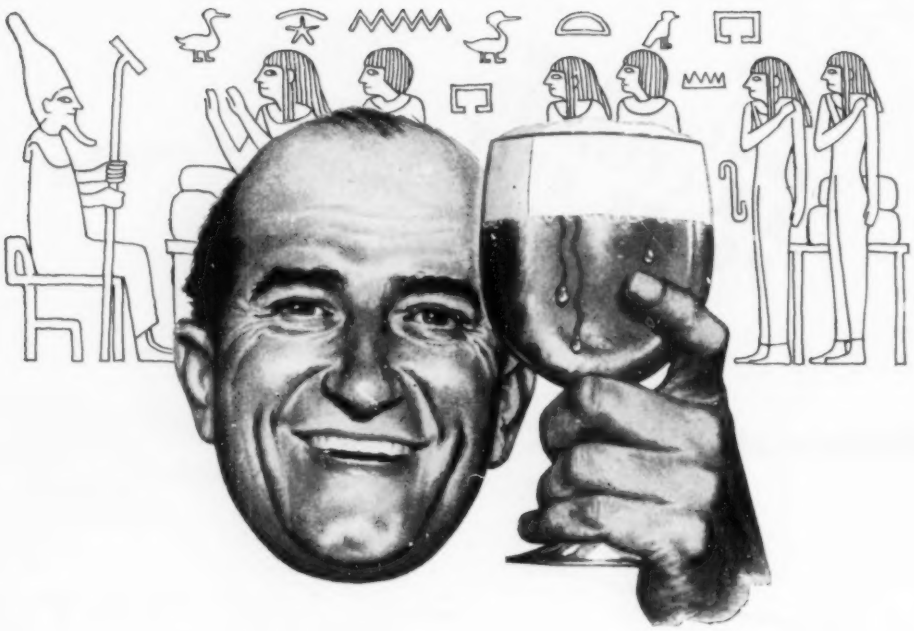
for this FREE Bulletin

Photographs, wiring diagrams, technical data, case histories, etc., on Bellows Air Motors, Hydro-Checks and other Bellows "Controlled-Air-Power" Devices. Shows how easy it is to use flexible, economical air power for "Faster, Safer, Better, Production." Address Dept. PE-651, The Bellows Co., Akron, 9, Ohio.

1256

The Bellows Co.

AKRON 9, OHIO



The Brewers uncovered a new wrinkle in an old, old science

THE ancient amber brew, you might call it. Brewing was a familiar art at least 5500 years ago by archeological record, and probably for many centuries before that.

In such a dynasty, the brewers naturally have run the gamut of materials for their equipment. Starting with the sun-baked clay of the ancients, ranging through wood and various metals, today the emphasis is increasingly on stainless steel in the never-ending search for higher quality and purity, finer taste and flavor, and lower overall costs. The bright, shining face of Allegheny Metal is to be found in equipment from one end of a modern brewery to the other, in the barrels on the trucks and in almost every tap-room.

The reason why is easy. No other available metal is at once as strong and as resistant to corrosion, heat and wear as stainless steel.

That's why Allegheny Metal is an essential material for so many industrial purposes—and for fighting equipment, too. We're steadily increasing our production, continuing to spend millions in the process—and as a further measure to spread the supply of stainless steel, we offer every assistance to users to avoid undue wastage and spoilage.

* * * * *

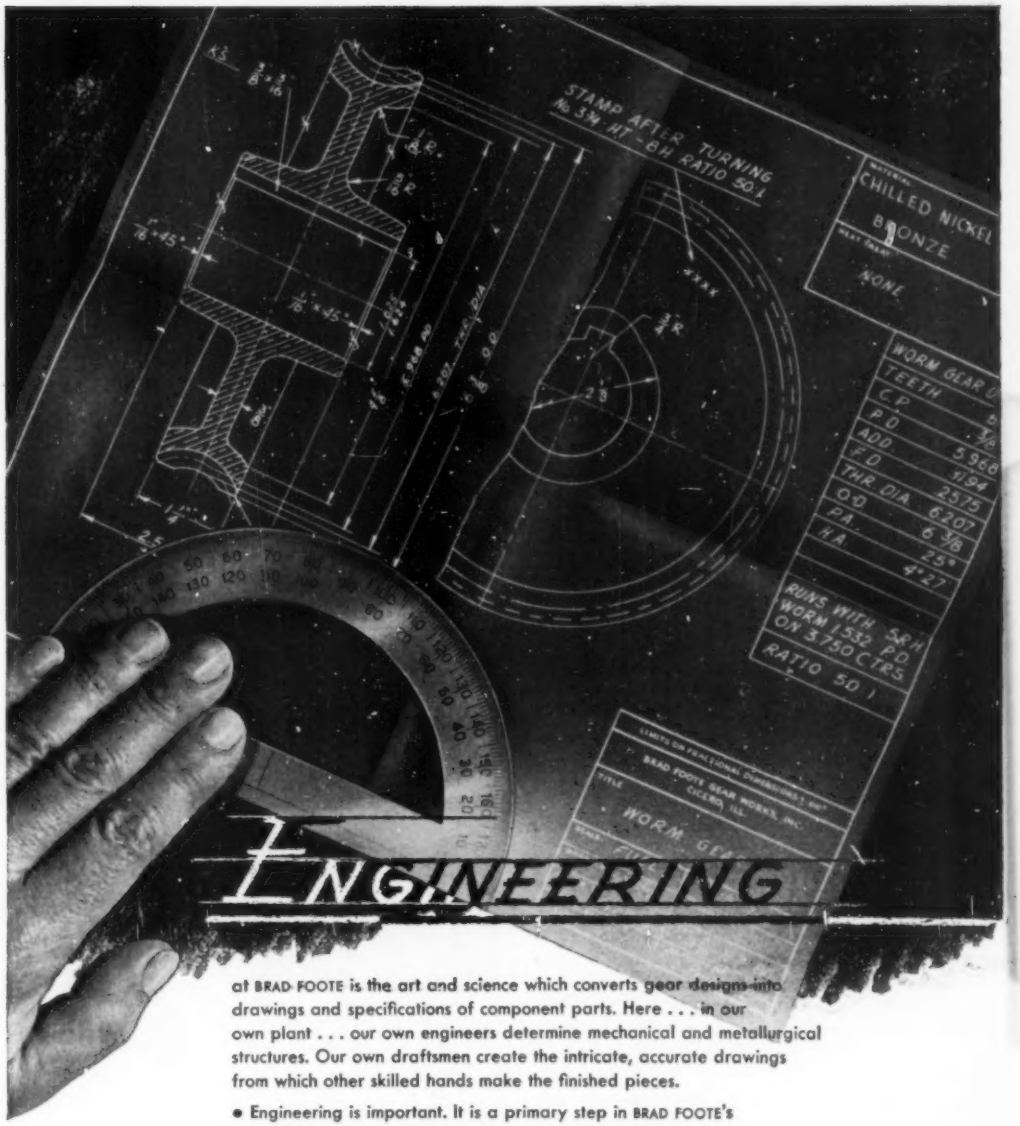
Complete technical and fabricating data—engineering help, too—are yours for the asking from Allegheny Ludlum, the nation's leading producer of stainless steel in all forms. Branch Offices are located in principal cities, coast to coast, and Warehouse Stocks of Allegheny Stainless Steel are carried by all Joseph T. Ryerson & Son, Inc. plants. ● Allegheny Ludlum Steel Corporation, Oliver Bldg, Pittsburgh 22, Pa.

WAD 3292

You can make it **BETTER** with

Allegheny Metal

AL
TIME-TESTED STAINLESS STEEL

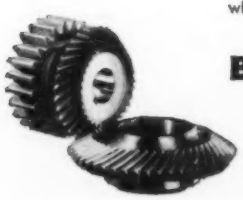


ENGINEERING

at BRAD FOOTE is the art and science which converts gear designs into drawings and specifications of component parts. Here . . . in our own plant . . . our own engineers determine mechanical and metallurgical structures. Our own draftsmen create the intricate, accurate drawings from which other skilled hands make the finished pieces.

• Engineering is important. It is a primary step in BRAD FOOTE's method of complete manufacturing control. It assures you of gears which will perform satisfactorily . . . when used in your shop or on equipment you sell to others.

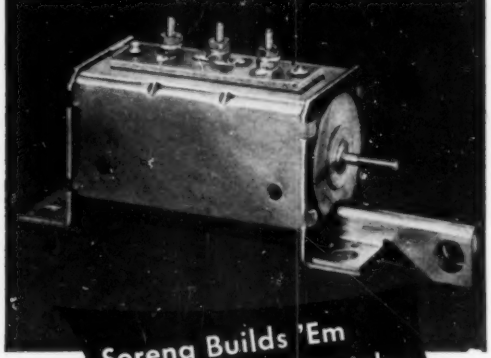
• This engineering service we give our customers is another reason why we can say—*"No one shares our responsibility."*



BRAD FOOTE GEAR WORKS, Inc.

Bishop 2-1070 • OLympic 2-7700 • 1309 South Cicero Avenue
Cicero 50, Illinois

need d-c solenoids?



Soreng Builds 'Em to Do A BETTER Job— LONGER!

Do *you* have a problem involving d-c solenoids? To get *more* work per unit volume—at lower cost, look to Soreng for d-c solenoids that do a *better* job *longer!*

Soreng-engineered d-c solenoids incorporate *exclusive* design features that assure—

- **More work with the most efficient use of copper and steel**
- **Elimination of the bottle-necks usually found in magnetic circuits**
- **Lowest practical weight and smallest size consistent with required work output**
- **Huskier construction for longer service life**
- **Lower cost**

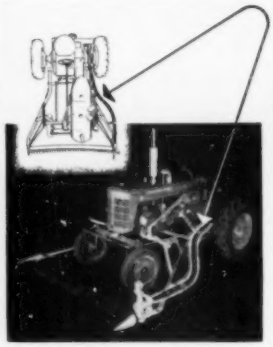
Typical of Soreng engineering is the d-c solenoid illustrated above. Designed for use on the hydraulic lift control of one of the nation's leading farm implements, it provides both push and pull, with a stroke of ⅛" in each direction. Operating on 6 volts d-c, it develops a force from 25 pounds in the open position to 50 pounds in the seated position.

Performance characteristics like these are the reason why so many of the country's major manufacturers rely on Soreng for solenoids that do a better job—longer. Want more information about d-c or a-c solenoids? Write, without obligation, to Dept. N16.

SM

America's Largest Manufacturer of Solenoids

Soreng Manufacturing Corporation
9555 Eden Ave., Schiller Park, Ill. (Chicago Suburb)
Plants: Schiller Park, Ill. • Fremont, Ohio



from any angle..

Annis Front-End Mower Manufactured by Krengel's, Inc., Twin Falls, Idaho

STOW FLEXIBLE SHAFTING SOLVES

Power Transmission Problems . . . BETTER!

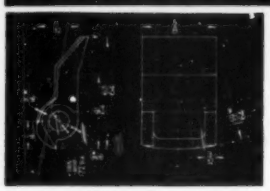
The problem: To provide a means of power transmission between power take-off and mower attachment that would give maximum efficiency — eliminate excessive vibration . . . eliminate danger of exposed rotating parts and costly clogging and jamming caused by dirt, grasses. Stow Flexible Shafting solves these problems — transmits power smoothly, safely, economically. Put Stow to work on your problems today!

Send for your free copy of Stow Flexible Shafting bulletin and Torque Calculator

STOW MANUFACTURING CO.
426 State St., Binghamton, N. Y.

MISCO *Precision* CARBON AND STAINLESS STEEL CASTINGS

CAST TO MICROMETER TOLERANCES



More than 500,000 castings of this piece have been produced to exacting physical and metallurgical specifications. Exceptionally high service stresses require critical inspection including 100% X-ray.

Part:
CORE CATCHER FINGER
(Oil well drilling equipment)
Alloy: Miscrome 4 (A.I.S.I. Type 410 Modified)
Weight: .06 oz.

This core catcher finger is similar to hundreds of different types of components that can be precision-cast with resultant economies in machining and material costs. The Misco Precision Casting Process provides low-cost quantity production of small, intricate alloy steel parts, uniform in quality, dimensional accuracy and soundness. Engineered for performance rather than convenience of fabrication, Misco Precision Castings can be readily adapted to products and manufacturing processes. Misco has superior quality alloys to suit your requirement; high strength hardenable, wear resisting, heat and corrosion-resisting steels. Misco has extensive precision casting technical experience and the necessary production skill. We offer assistance with design, production and application of precision cast parts that must resist heat, abrasion and corrosion.

PRECISION CASTING DIVISION
Michigan Steel Casting Company
1999 GUOIN ST. • DETROIT 7, MICH.
MISCO — One of the World's Pioneer Producers and Distributors of Heat and Corrosion Resisting Alloys

Bunting Cast Bronze Bearings lend themselves readily to simple, clean design—only a straight shaft, a bearing of finely finished bearing bronze, a housing surrounding it and the oil film to insulate against noise and wear. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in principal cities.

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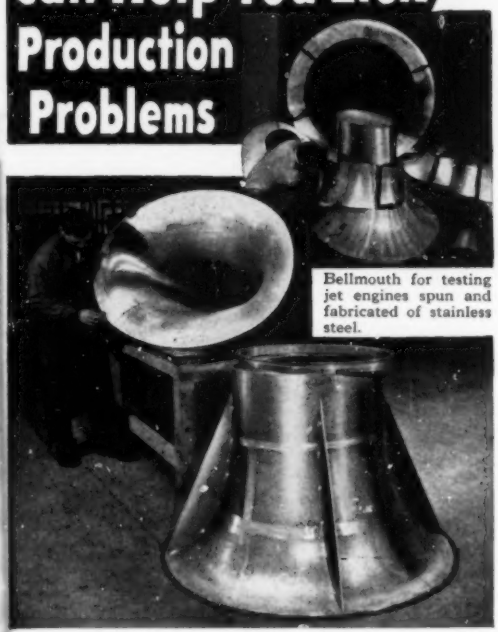
Cut the cost of dies
Gain weeks of time

Spincraft
SKILL WILL DO IT

spinning and fabricating
can Help You Lick Production Problems



Bellmouth for testing jet engines spun and fabricated of stainless steel.

HIGH tooling costs — months of waiting time — the urgency of the hour — these very real conditions need not bring despair to able designers and alert production executives. Spincraft engineering may well provide you with a welcome solution at a small fraction of conventional fabricating costs and in far less time.

The parts or products you see here reflect what can be done by spinning and fabricating in combination. This resourceful approach provides a wide range of opportunities in many metals that you are invited to discuss with Spincraft engineers. The answer you want cannot be guaranteed, but others have been helped so often and so well that Spincraft has become the world's largest metal spinning and fabricating plant. Call or write

Send for the Spincraft Data Book—40 pages of engineering information that will be helpful to you.

Spincraft
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INCORPORATED

4139 W. State St.
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Heretofore known as Milwaukee Metal Spinning Co.

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COMPACT, RUGGED, PRECISION BUILT FRACTIONAL H. P. ELECTRIC MOTORS

1/1000 H. P. to 1/4 H. P.

For 25 years, OSTER has specialized in building fractional H.P. motors to meet specific requirements. OSTER is unsurpassed in engineering, tooling, and assembly of electric motors up to 6" maximum O.D. of the following types:

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Shaded pole motors—conventional voltages
400 cycle motors of the smaller sizes
Also precision electro mechanical assemblies

All this OSTER experience and precision workmanship, plus the considerable volume of fractional H.P. electric motor production, assures you a reliable source for motors of dependable performance. For full information as to how OSTER can serve your special motor needs, write, wire or telephone

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MANUFACTURING CO.
RACINE, WISCONSIN

Skinner Solenoid Valves

M-2 Bronze Body Diaphragm Valves M-3

for air conditioning, packaging, refrigeration, air, printing equipment, etc.

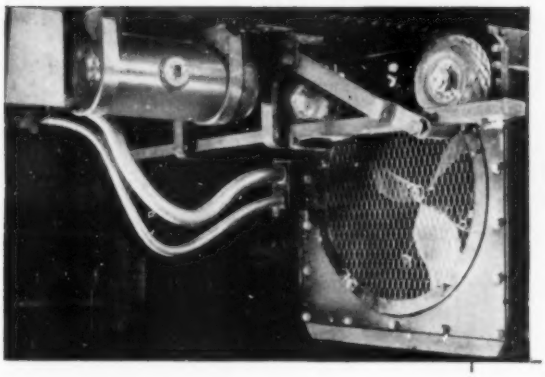
The "M" Series valves are approx. 4⅝" high, yet have extremely fast action and large capacity for liquids, air and inert gases! They have soft insert seats to prevent leakage — will operate in any position — nylon fabric coated diaphragm for long life — max. power consumption 10 watts — continuous duty! **M-2** two-way normally closed — 5 to 150 p.s.i. — port size ⅜" or ½"; orifice ⅜" — pilot operated. **M-3** three-way normally closed, three-way normally open or directional flow—20 to 150 p.s.i. — port size ⅜" or ½"; orifice ⅜" — pilot operated. Special models available.

Write for Bulletin No. 493

SKINNER ELECTRIC VALVES

Skinner ELECTRIC VALVE DIV.
THE SKINNER CHUCK COMPANY
132 Belden Ave., Norwalk, Conn.

would a **flexible** connector help your product "*move*"?



squirts around corners

American asbestos-packed Flexible Bronze Tubing makes a flexible spout for this pistol type oiler made by the Plews Oiler Co.

rides the rods

These flexible refrigerant lines of American Seamless Bronze Tubing with a bronze protective casing permit this Waukesha Motor Co. railroad car air-conditioning unit to be rolled out for servicing and inspection. Pressure-tight and rugged, American Flexible Metal Connectors stand up under tough working conditions.

a flexible suggestion

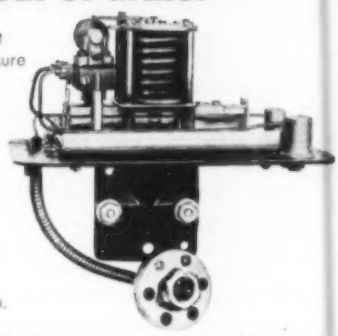
in engineering your product: there's an American Flexible Metal Connector for every connector problem – for eliminating vibration, for cramped connections, for misaligned ports, for moving parts. Strong, tight and corrosion-resistant.

Write for Bulletins SS-50 and CC-300 to The American Brass Company, American Metal Hose Branch, Waterbury 20, Connecticut. In Canada: The Canadian Fairbanks-Morse Co., Ltd.

51236

modern coat of armor

This Taylor Instrument Co. "Transaire" Pressure Transmitter uses 3/16 in. I.D. American Stainless Steel Tubing as a protective casing for the delicate capillary tubing connecting the volumetric pressure element with the instrument mechanism.



holds the curves

This Porta-Flex bench and machine light, made by Detroit Industrial Products Co., takes any curve and holds it. Its special heavy-duty American Steel Tubing remains both tight and flexible and withstands vibration. Base permits either vertical or horizontal mounting.

ANACONDA

wherever connectors must move . . .

American **FLEXIBLE METAL HOSE AND TUBING**

another tough cold heading job by SCOVILL

This copper transformer stud is being produced by cold heading at Scovill for a well-known electrical manufacturing company. Note the different diameters and shapes, the staked wings and "captive" fiber washer. Copper, though difficult to work on automatic screw machines, is admirably suited for cold heading. By preserving the flow lines in the metal, cold heading also produces a stronger part.

Although this particular part is designed for an electrical component, it may spark a solution to some similar problem you have, involving different diameters, washer assembly and staked wings. For further information send your sample or blueprint.

"Guide to the Profitable Use of Cold Heading" —Bulletin No. 2 describes the advantages and limitations of this process for the designer. It's free for the asking.

A PRODUCT OF SCOVILL

RECESSED HEAD SCREWS • SEMS • TAPPING SCREWS
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HEINZE
SUB-FRACTIONAL HORSE POWER MOTORS

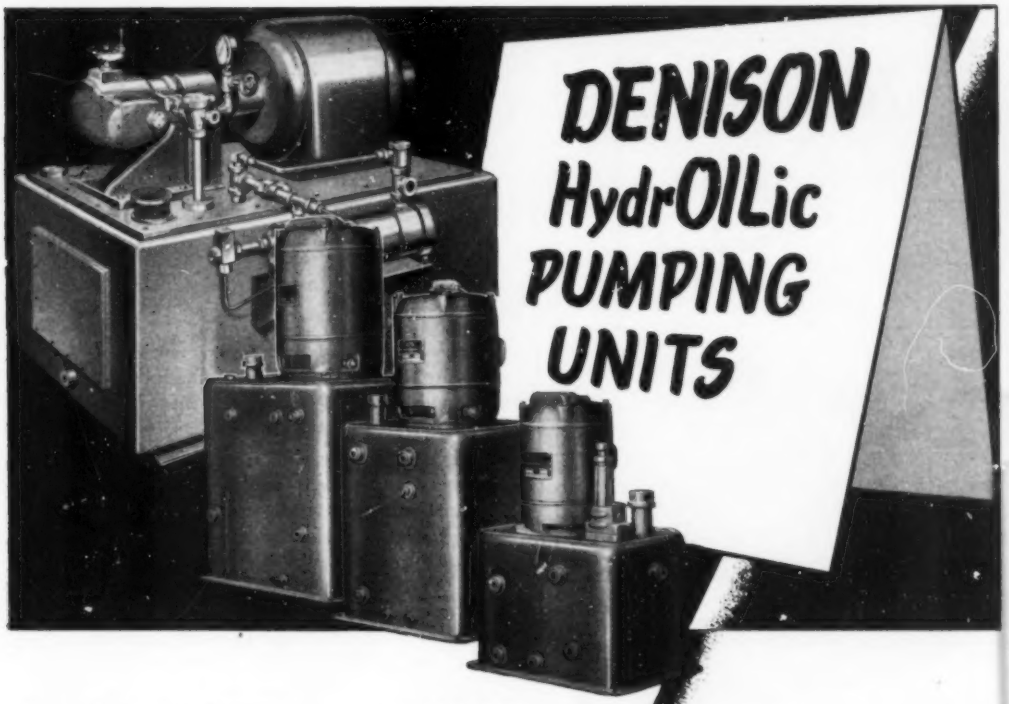
TYPE F BLOWERS

Originally designed for cooling electronic tubes in transmitters, induction heaters and diathermy equipment, Heinze F2 Blowers have become popular also for advertising displays and similar applications where a small current of air and quiet operation are required.

Characterized by low wattage, neat appearance and light weight. The shaded pole motor will not cause radio interference.

115v AC 60 cycles 15 watts
F2D (double) 20 CFM 3000 RPM (free air)
F2S (single) 10 CFM 3000 RPM (free air)

Heinze Electric Co.
685 Lawrence Street
LOWELL, MASS



For Circuit Pressures to 5000 psi

For *any* hydraulic circuit need—with any pressure capacity up to 5000 psi—one of the 37 different models of HydrOILic Pumping Units will give you highest efficiency in a rugged, compact, space-saving package.

The HydrOILic Axial Piston Pumps that form the heart of these pumping units have been shown by repeated tests to deliver high volumetric efficiency at operating pressures up to 5000 psi. They are hydraulically balanced throughout, with fewer parts and simplified construction that means longer service with lower maintenance costs.

The advanced performance attained in HydrOILic Pumping Units is the result of more than 25 years of specialized engineering and manufacturing experience at Denison—experience *concentrated* in the field of oil-hydraulic equipment. Their advantages have been proved by users in almost every field, under all types of operating conditions.

For best results on your hydraulic circuit needs, use Denison HydrOILic Pumping Units, Valves, Controls, Fluid Motors, and Pumps. Write for complete information.

37 different types and sizes ● Operating pressures from 400 to 5000 psi ● Constant or variable volume types ● Volume control by handwheel, stem or pressure compensation ● Volume deliveries from 2 to 35 gpm ● Efficient axial piston pumps ● Reservoir capacities from 16 to 165 gallons ● Single-panel mounting of motor, pump, relief valve, gauges and controls ● Available with thermostatically controlled cooling systems ● Compact design simplifies circuit arrangement ● Large series units meet J. I. C. standards.

DENISON HydrOILics

The DENISON Engineering Company
1157 Dublin Rd. Columbus 16, Ohio

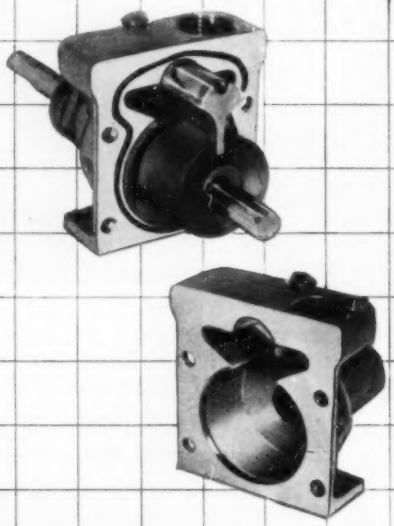
ONCE A SPECIALTY... **NOW MASS-PRODUCED**

PRODUCTION OF STAINLESS STEEL PUMPS FAST and ECONOMICAL WITH "HAYNES" PRECISION CASTINGS

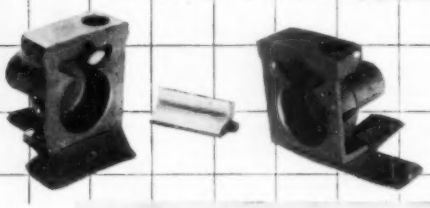
Stainless steel gearless pumps were strictly a "specialty" item with a New Jersey pump manufacturer until investment castings were put to work. They are now being mass-produced as a standard item.

Fabrication of the pumps is easy and economical. The precision investment castings—two body sections and an impeller guide—require only a few finishing operations before assembly because they are cast so close to size. For this reason, there is no excessive waste in machining. The parts have a sound, dense structure, and the surfaces are exceptionally smooth. Even the lettering that identifies the manufacturer, the model, and the patent numbers is cast so precisely that it is clear and legible.

Use of HAYNES precision investment castings has thus made it possible to produce pumps with excellent appearance and long service life at attractive prices. For examples of other successful applications of these castings, and also tips on designing parts to be produced by this method, write for the booklet, "Investment Castings."



Use of investment castings (right) for the three metal parts of stainless steel gearless pumps (above) has enabled a New Jersey manufacturer to mass-produce the pumps.



HAYNES TRADE-MARK *alloys*

"Haynes" is a trade-mark of Union Carbide and Carbon Corporation.

Haynes Stellite Company
A Division of
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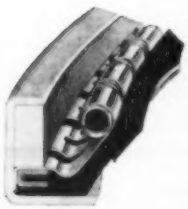
Los Angeles—New York—San Francisco—Tulsa

Bearings are COSTLY

PROTECT Them with Garlock KLOZURES

Model 63—An efficient, general purpose seal for high speeds. For shafts 3" diameter and smaller.



Model 64—A strong, effective seal for heavy duty on shafts of the largest diameter.

Model 53—An efficient, general purpose seal for high speeds. For shafts above 3" diameter.

Model 91A—A springless seal of small cross section, with the metal reinforcing member surrounded by rubber.

Model 91B—A spring-loaded seal of small cross section, with the metal reinforcing member surrounded by rubber.

IT'S certainly good business practice to buy the *best* oil seals, in order to have maximum protection for costly bearings. By using the proper KLOZURE oil seal, you may save the high cost of frequent bearing replacement.

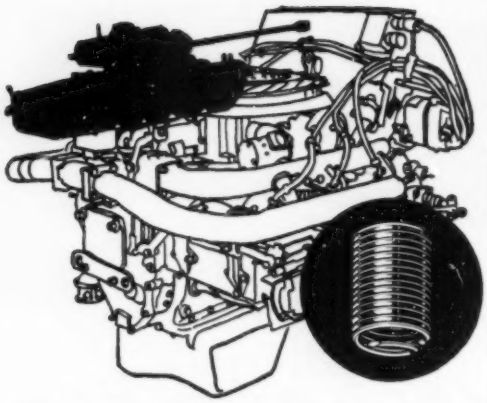
To be sure of thoroughly dependable bearing protection, specify Garlock KLOZURE Oil Seals. They are tough and durable, resist oil and heat, stay firm and resilient. KLOZURES are made in a complete range of sizes and in many models, a few of which are illustrated.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

In Canada: The Garlock Packing Company of Canada Ltd., Montreal, Que.

GARLOCK Klozure* OIL SEAL

*REG. U. S. PAT. OFF.



PROTECT ALL ASSEMBLIES AGAINST SCREW THREAD FAILURE

Use Heli-Coil Inserts of precision-formed stainless steel or phosphor bronze wire. They give permanent armored protection to all threaded members. They ELIMINATE vibration-wear, failure and stripping . . . also galling, seizure, and corrosion, even in the presence of salt air, dampness and tropical humidity.

Assembly and disassembly, however frequent, are easily and quickly done with no thread wear. Production salvage and field repair of damaged or defective threads are simplified. One ordnance manufacturer salvaged over $200,000 worth of castings in a year. Specially designed Heli-Coil ordnance kits are approved for base and field service.

Heli-Coil Inserts are widely used in jet and reciprocating engines — nearly 600 in one famous engine! — in airframes and accessories, in gun-mounts, radar and electronic instruments, fire-control mechanisms, transmissions and many other products. Heli-Coil Inserts fit National Coarse and Fine Thread sizes, pipe threads, all automotive and aviation spark plugs. Meet all industrial, military, and aircraft specifications. Class 2, 2B, and 3 fit.

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Protecting Screw Threads for Industry

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HELI-COIL CORPORATION
47-283 Thirty-Fifth Street, Long Island City 1, N. Y.

Please send me ☐ Bulletin 650 on Design Data
☐ Bulletin 349 on Salvage and Service

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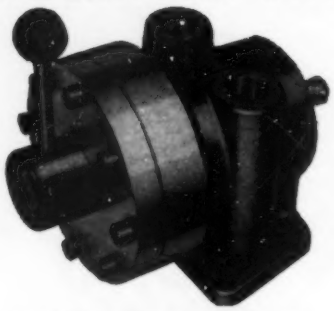
The *Controlled Flow*



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PROVIDES COMPLETE CONTROL OF
VOLUME • • • DIRECTION • • • PRESSURE
AT THE PUMP without Valves

These are only some of the features that the HYDROPUMP offers. For complete information, write for Bulletin 100-P.

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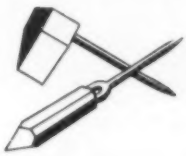
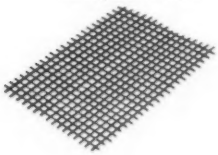


INDUSTRIAL WIRE CLOTH and
BRASS STRAINER CLOTH



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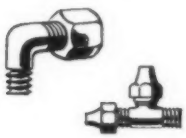

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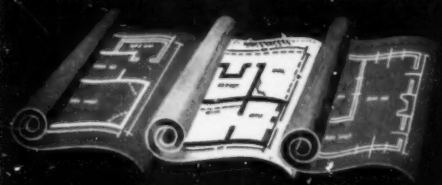

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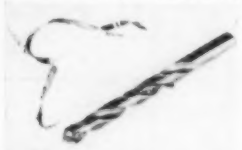
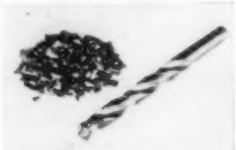
Simplifies Production of Precision Parts

Applications for INVAR:

Invar in the forms of bar stock, strip and tubing is frequently used to advantage for parts which must not change size with temperature variations. Typical applications include instruments, aircraft controls, and other devices that must remain accurate in spite of temperature changes from 0 to 400°F. Another use is in providing movement for automatic control, by combining invar's low thermal expansion rate and the higher expansion rate of another metal. Many thermostatic devices employ this principle.



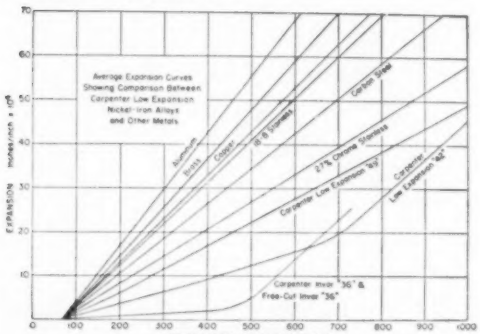
Tool used and chips produced in drilling regular grade invar.



Tool used and chips produced in drilling Carpenter Free-Cut Invar "36".

Free-Cutting INVAR:

Note that the drill used on regular invar failed after going only 1⅛", while the drill used for Carpenter Free-Cut Invar "36" was still good after drilling through the entire 2⅜" block. Carpenter Free-Cut Invar "36" is easy to machine, yet has the same low thermal expansion characteristics as the regular Carpenter Invar "36", as indicated in the graph shown here.



The Carpenter Low Expansion Alloy Book gives you useful information on the expansion characteristics of the two Carpenter 36% nickel invar alloys. For a copy, just write a note on your company letterhead, indicating your title.

THE CARPENTER STEEL COMPANY
117 W. Bern Street, Reading, Pa.

Export Department:
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Carpenter

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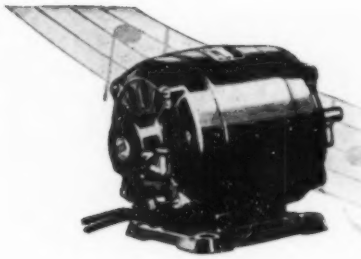
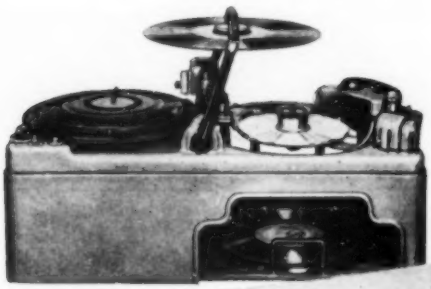
offer you new opportunities to solve problems



Lincoln RECORD CHANGER uses a BODINE MOTOR

Twenty-one hours of continuous record music from only one loading is now possible with the Lincoln Record Changer. Totally unlike any other record changer, it utilizes air as the motive power for transferring each record to the turntable and for turning it over. Warped and rough or chipped edged records can be played as easily as records in perfect condition. A Bodine Type NCI-34 Motor powers the vacuum pump.

A Bodine Motor, tailored to fit the particular characteristics of your application, will insure your product top motor performance, quality and appearance. There are over 3,500 standard Bodine Motors—the widest variety of types and ratings (1/2000 to 1/6 HP) in the fractional horsepower field—available for you to choose from. Nearly a half a century of motor experience is built into every Bodine Motor. It will pay you to consult Bodine engineers.



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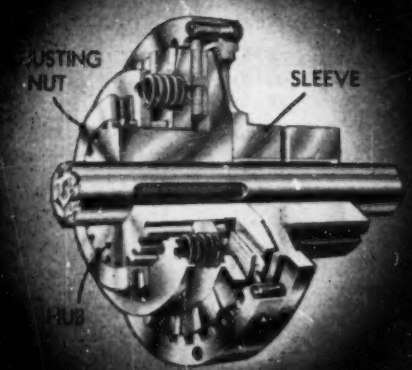

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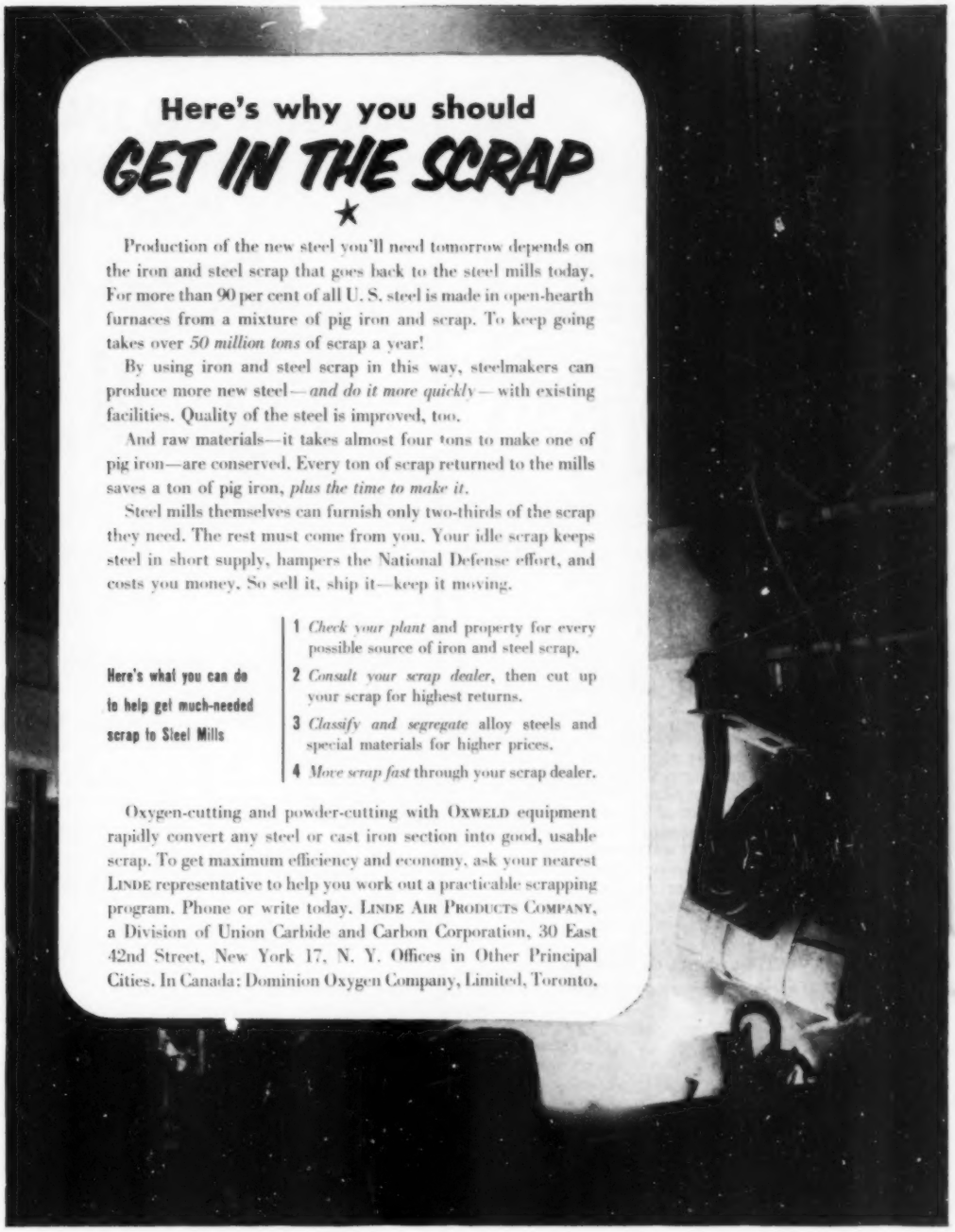

Here's why you should

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Production of the new steel you'll need tomorrow depends on the iron and steel scrap that goes back to the steel mills today. For more than 90 per cent of all U. S. steel is made in open-hearth furnaces from a mixture of pig iron and scrap. To keep going takes over *50 million tons* of scrap a year!

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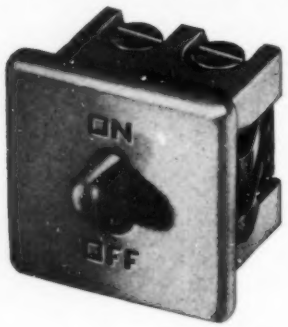

Manufacturers of such diverse products as blue print machines and x-rays, test panels and refrigerators, hot plates and ironing machines, as well as electronic, restaurant and air conditioning equipment, get significant savings in assembly time and space utilization with this "Diamond H" 2160A switch.

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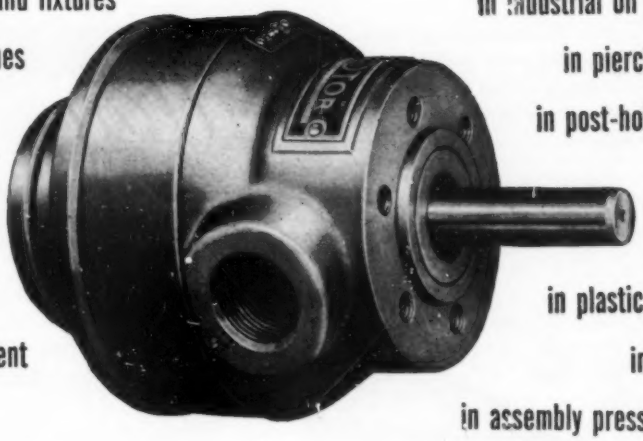

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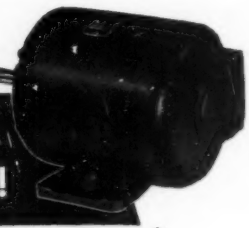

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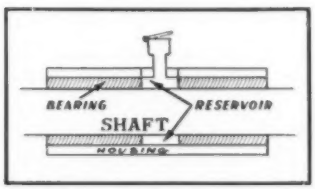
The Lubrication of Sleeve Type Bearings-2

NO BEARING, regardless of type, will operate satisfactorily or for any length of time without proper and dependable lubrication. The lubricant, as the life blood of every motive unit, should be the correct type, the right consistency and always in the right place at the right time. Otherwise excessive heat, wear and friction will develop with eventual seizure and bearing failure. The most popular lubricating agent is oil, with grease in some applications and graphite, water or other fluids used to a lesser degree.



In applications where it is necessary to use a longer than usual bearing, we sometimes recommend the use of two short bearings with the intervening space to serve as an oil reservoir.

The ideal bearing application is one in which it is possible to achieve a state of fluid friction with the journal and the bearing completely separated. The only friction present then is in the shearing action of the layers of oil. Obviously such an application would only be possible where there are high speeds and light loads. But as all bearing applications are not ideal, the designer must have ways and means to come as close as possible to ideal lubricating action.

Obviously, the first step is to assemble all operating facts. Then the method of distributing the lubricant and the type of lubrication to be used can be decided. Fundamentally, there are four primary methods of distributing the lubricant when it is oil —i.e., force feed . . . splash . . . bath . . . and ring, chain or collar oiling. In selecting the method to use, the most important factor to bear in mind is reliability.

Force feed is sometimes referred to as circulating lubrication. It includes all applications wherein a continuous flow of oil is maintained throughout all bearing applications. In such systems the viscosity of the lubricant is an important feature. It is also necessary to provide some method of purifying the lubricant for repeated use. Other considerations include speed, which should be high enough to build an oil film; dissipation of heat; prevention of leakage and oil oxidation. In some cases it is advisable to provide an oil cooling system to maintain the proper operating temperature of the lubricant.

The splash system involves the use of a completely enclosed crankcase, usually a cooling system and a heavy oil. As lubrication is effected by dipping, this system must provide an indicator so that the proper oil level is always maintained.

In the bath system the operating parts are usually completely submerged in the lubricant. In this method practically the same factors are involved as in the splash method.

Ring, chain or collar oiling involves a system whereby the lubricant is carried from the reservoir to the bearing by a ring or collar that rotates with the shaft to an opening in the top of the bearing. In this system particular attention must be paid to the type of oil grooving of the bearing so that sufficient oil is carried into every part of the loaded bearing area.

Hand oiling can be utilized in some applications although it is usually best to provide an oil cup or a combination of cup and wick.

Up to this point methods of supplying oil lubrication have been outlined. However, in many applications, use must be made of grease due to the nature of the operating conditions. Grease is ordinarily used for rough machinery where usage is severe and clearances are not consistent, and in slow moving equipment since the laws of hydrodynamic action are ineffective.

It is recommended that greases be supplied by some pressure system or pressure guns, since adjustable grease cups give positive action.

In conjunction with lubricating systems consideration must also be given to prevent end or side leakage. This condition in bearings is undesirable because it reduces the load a bearing may safely carry and results in extensive oil waste which creates problems of cleanliness both on the machine and goods in process.

In order to prevent this condition use should be made of proper oil seals which, in addition to conserving oil, keep dirt from entering the machinery.

In all applications in which lubrication is required it is desirable that repeated use be made of the lubricant for reasons of economy. However, it must be remembered that oil is certainly to become contaminated while it is being used and this contamination definitely reduces the effectiveness and efficiency of the lubricant, resulting in injury to bearing surfaces.

Air, in the presence of hot oil, results in oxidation and the formation of sludge. These sludges are often acid in character and are injurious to the bearing linings. In many applications water is prevalent and in mixing with the lubricant tends to dilute the lubricant and make it ineffective as a load carrying medium. In addition, high temperatures are extremely destructive to oils and cause vaporization of the lighter constituent and the formation of carbon. In order to assure clean, suitable oil, two methods are generally used, that of filtering or separation by gravity.

Obviously some methods of lubrication are more expensive than others. There are many ways of reducing costs in designing machinery but the selection of an inferior or inadequate system of lubrication is not one of them. The most expensive bearing in the world is the one that fails. The easiest way to be certain of getting the greatest value and performance out of your bearing applications is to consult with Johnson Bronze. Our engineers are fully competent to give the proper advice and assistance on all your bearing problems. They will work with you without obligation.

In some bearing applications it is often possible and practical to provide recesses on the outside diameter of the bearing which serve as oil reservoirs.

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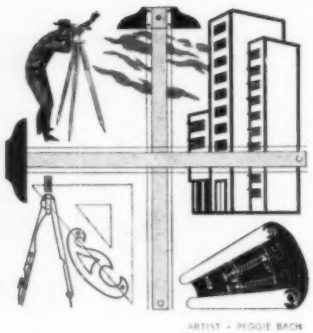

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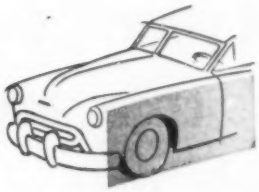

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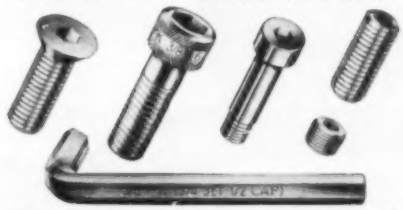
REMEMBER — IF IT'S P-K . . . IT'S O.K.*



Flat Head Socket Cap Screws • Size-marked Socket Head Cap Screws
Stripper Bolts • Ground Thread Socket Set Screws • Pipe Plugs • Hex Keys
Available Through Accredited Distributors.

*Trade Marks Reg. U. S. Pat. Off.

PARKER-KALON*
cold-forged
SOCKET SCREWS

Davidson
RUBBER COMPANY

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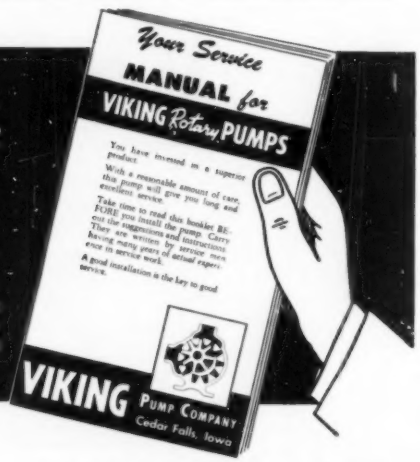
INDUSTRIAL RUBBER PRODUCTS

Solid, hard or sponge rubber parts molded to customers specifications from natural, synthetic and reclaimed rubber

Davidson RUBBER COMPANY
"Established 1857"
BRIGHTON STREET Department 5 BOSTON 29, MASS.

HELP YOURSELF To More and Better PUMP SERVICE



VIKING
AN HONORED NAME IN PUMPING

With this illustrated booklet, you can help yourself to more efficient, economical service from your Viking Rotary Pumps. Defense needs now require part of our production. We strongly urge, therefore, that users follow instructions in this FREE manual X to help maintain longer service from your Viking Pumps.

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Cedar Falls, Iowa

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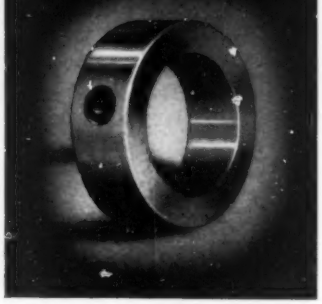
with
UNBRAKO
Self-Locking
HOLLOW SET SCREWS



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by manufacturers of such widely diversified products as *lawn mowers, food machinery, textile machinery, juke boxes, snow plows, conveyors, air compressors, agricultural machinery, electric fans, bottling machines,* and dozens of others.

Precision machined from solid bar stock in 42 stock sizes for shafts from 3/16" to 3" diameters inclusive.

Write for prices and name of your nearest distributor.

SPS

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JENKINTOWN 28, PENNSYLVANIA

ONLY ONE COMPANY CAN PROVIDE

THIS *Unique 4-Point Plastics Service*

1 DEVELOPMENT OF SPECIAL PLASTICS MATERIALS

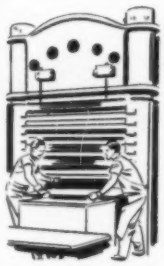
The Richardson Company maintains complete laboratory facilities for the development of new plastics materials—including various combinations of resin, rubber, and other materials—for special applications.

2 ENGINEERING DESIGN OF SPECIAL PLASTICS PARTS

Richardson will handle your plastics problem from beginning to end: analyze your requirements; help design for performance, appearance, and low cost; and develop the material and process best suited to your needs.

3 COMPLETE MOLDING FACILITIES

With its six plants, Richardson is one of the world's largest molders of plastics. Its processes include compression and transfer molding of thermosetting materials and injection molding of thermoplastic materials.



4 COMPLETE LAMINATING FACILITIES

INSUROK laminated plastics are made in all standard grades, plus many exclusive special grades, in sheets, rods, and tubes. Richardson also produces PLASTOK decorative laminate in many patterns, colors, and sizes.

FOR YOUR SPECIAL PLASTICS JOBS *Consult* *The* RICHARDSON COMPANY

For a better plastics part at a lower cost, it pays to consult The Richardson Company. For Richardson is the only large manufacturer in the industry that develops new plastics materials and produces laminated and molded plastics, molded laminates and post-formed laminates. Because of this versatility, Richardson is in a position to help engineer your product for the most efficient and economical method of production.

FOUNDED 1858—LOCKLAND, OHIO

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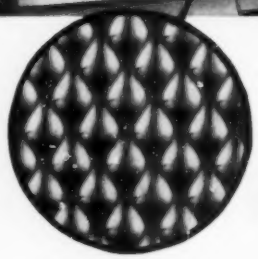


Full size photograph of RIGIDIZED METAL Pattern 6-WL

made of

Rigidized

DESIGN STRENGTHENED **Metals**

When Hotpoint, Inc., installed RIGIDIZED METAL decking in their commercial ovens in place of conventional decking, maintenance costs were greatly reduced. This durable metal does not have the susceptibility to damaging heat warpage. RIGIDIZED METAL oven flooring prevents burned-bottom baked goods because of the easy passage of air along the 3-DIMENSIONAL patterns. Baking heat is reached faster than is possible with conventional flooring.

The 3-DIMENSIONAL design-strengthened qualities of this modern metal are applicable to products in every industrial and commercial field. RIGIDIZED METAL makes possible lighter weight with added strength, CONSERVATION OF CRITICAL MATERIAL, surface protection and longer life, *PLUS* eye-sales appeal. In use today in buildings, trains, planes and many other applications, there is a RIGIDIZED METAL that will give your product added value.

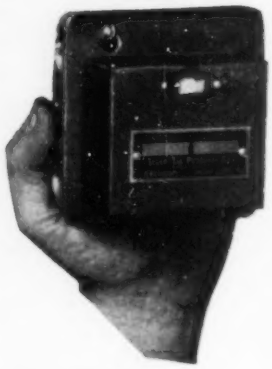
Investigate these possibilities!

Send for your copy of the
Rigidized Metals IDEA Handbook
TODAY

Rigidized Metals Corporation

673 OHIO STREET, BUFFALO, N. Y.

ULTRA-SENSITIVE ELECTRONIC RELAY



FEATURES

SENSITIVE — Relay action initiated by external contact as high as ONE HALF MEGOHM with current as low as 1/10000 ampere.

LOW COST — Electronic sensitivity and features at a cost comparable to ordinary relays.

SMALL SIZE — Mounts on a standard 4 inch electrical connector box.

DEPENDABLE — Simplified circuit plus silver relay contacts assures long service life.

ECONOMICAL — No tube filaments to consume power during "OFF" cycle.

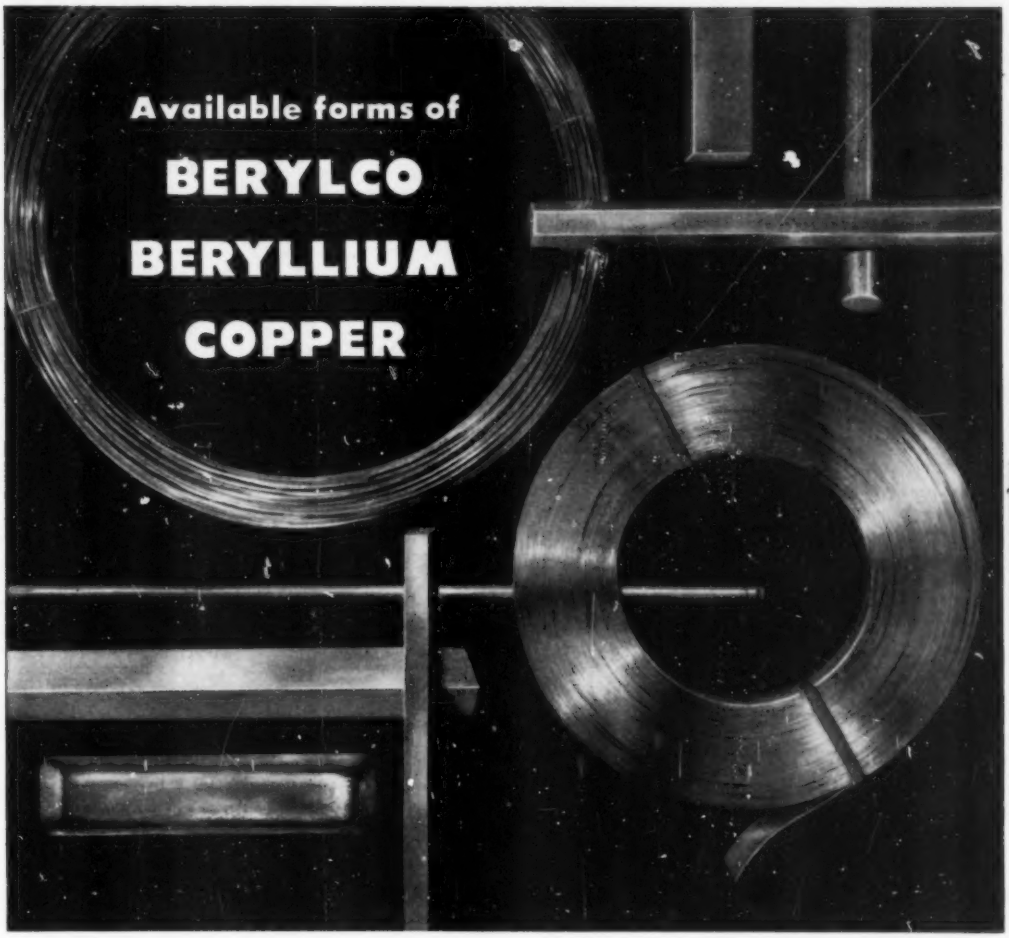
VERSATILE — High contact pressure on silver contacts allows conservative rating of four (4) amperes, with a choice of either opening or closing a circuit, or to simultaneously open one and close another.

AUTOMATIC HOLD CIRCUIT — Connecting terminals provide a choice of conventional relay action, or allow a momentary contact to energize relay and cause it to automatically remain energized until manually reset by "Reset" switch.

APPLICATIONS

LIQUID LEVEL CONTROLS
SAFETY ALARMS
STOP MOTIONS
DROP WIRE DETECTION

Servo-Tek products co
4 Godwin Ave. Paterson, N. J.



You can buy Berylco in casting ingots. You can buy it as rod and bar, in rounds, rectangles, hexagons or squares. You can buy it as heat-treatable and pre-tempered wire . . . or as cold-rolled, slit-edge strip.

However you buy it, Berylco will give you a unique combination of properties not otherwise obtainable. To find out what Berylco can do for you, take advantage of the technical knowledge of the world's largest producer of beryllium copper. Blueprint your problem—or send for sample material.

The Beryllium Copper Technical Bulletins, issued monthly, are full of helpful information about end uses. To receive your copy regularly, write on your business letterhead.

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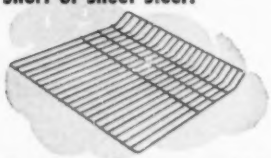
Problems Like These?

Short of Sheet Steel?



Try a Welded Wire Assembly!

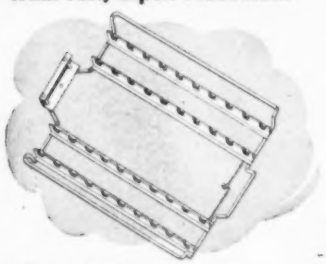
This Titchener-made tray for an ice cube machine replaces a stainless sheet steel piece. *Advantages: A better product.* Water now drains through — no longer overflows as it did with original stamping. *Lower cost.* Tooling was negligible, compared to expensive die required for the stamping. *Immediate availability.*

Using Expensive Castings?

Change to a Wire Form!

There's an increasing trend toward substitution of wire and wire-strip assemblies for castings, forgings and machined parts. This solder pot holder is an example. Stronger and lighter than a casting of like size, it is safe, unbreakable, far less costly.

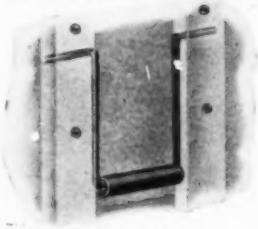
Want Fast, Expert Production?



Wire and Strip Assemblies— On Time!

Mass production of complicated designs is a Titchener specialty. This heating element rack requires 49 punched holes, 23 bends in heavy wire, 12 bends in strip steel and 22 spot welds — all punched, formed, assembled, welded in surprisingly fast time . . . and at minimum cost.

Need Help on Sub-Contracts?



Come to Wire Goods Headquarters!

For 65 years and through two World Wars, Titchener has worked closely with prime contractors in meeting government specifications on such parts as this ammunition box handle. Our experience with every conceivable type of wire and strip part can lick just about any problem you bring us.

TELL IT TO TITCHENER!

If your problem involves wire forms, welded-wire assemblies or wire-and-strip-steel items — Tell it to Titchener. Titchener offers you . . .

1 — Design Assistance
2 — Sample Making
3 — Tool & Jig Making
4 — High Volume Production
5 — Plating & Finishing
6 — Prompt Delivery

Send us your prints — or describe your requirements in a letter. No charge for our suggestions.

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FOR MOULDING OR COATING

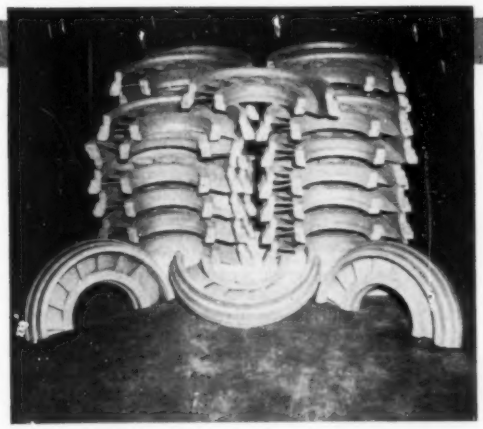
ORGANOSOLS
FOR FABRIC OR PAPER COATING
. . . FOR DIPPING

For today's defense program Stanley Plastisols and Organosols can be formulated to meet rigid government specifications with emphasis on low temperature flexibility and resistance to fungus. For tomorrow's competitive selling they'll assure greater durability and sales appeal for your product. Write today and take advantage of our years of experience in the vinyl field: Stanley Chemical Company, 81 Berlin Street, East Berlin, Conn.

STANLEY *Industrial Coatings*

STANLEY CHEMICAL
LACQUERS JAPANS SYNTHETICS ENAMELS

Do these Nozzle Rings suggest an idea for *Your Product?*



Nozzle rings used as part of the air scoop on superchargers for diesel locomotives. Hub of Chemalloy N-1 is cast around a number of forged stainless steel blades.

Specify THERMALLOY* for heat and abrasion resistance ... CHEMALLOY* for corrosion resistance

Your alloy casting requirements may be far removed, both in physical form and end use, from the nozzle rings shown here. Yet they may suggest a practical way in which our facilities and experience can be of special value.

Pertinent facts:—a hub of CHEMALLOY* N-1 (Ni-resist type 1) is cast around a number of forged stainless steel blades. The blades must be securely held in place, and the finished casting machined both in the bore and outside diameter. We worked closely with the customer to produce a satisfactory casting with more blades and closer spacing—thus increasing the efficiency of the air scoop.

The casting job itself is a particularly difficult one. But because these units are required in quantity, we have been able to devote considerable engineering time to working out the foundry methods which will produce the best possible casting.

We like to work this way—where volume is sufficient to insure economical production and close quality control of all processes. If you have such a need for high alloy castings for resistance to heat, abrasion or corrosion, we'll be pleased to have a sales engineer call. Write Electro-Alloys Division, 2122 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

PAG
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3 IMPORTANT BUYING QUESTIONS

must be answered . . . .

when you need Electrical Components or Equipments

WHO makes a product that will do your job?

WHICH makes are best suited to your requirements?

WHERE are the nearest sources of supply?

If it's *electrical* you can find the answers to all three questions in the McGraw-Hill ELECTRICAL CATALOGS. "Who" and "Where" may be found in the directory section of all known electrical manufacturers. The "Which" may be compared in the pages of manufacturers' catalog data.

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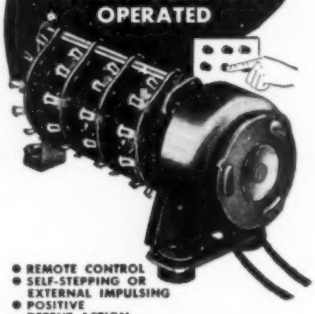
LEDEX

RELAYS and CIRCUIT SELECTORS

ROTARY SOLENOID OPERATED



- REMOTE CONTROL
- SELF-STEPPING OR EXTERNAL IMPULSING
- POSITIVE DETENT ACTION

for REMOTE CONTROL of MULTIPLE COMPLEX CIRCUITS

Many versatile designs of stepping, counting, adding and subtracting, latching, and *circuit selecting* relays are made possible by the combination of the Ledex Rotary Solenoid and wafer type rotary switches. Self-stepped or externally impulsed, the device is immediately adaptable to many remote control applications. A choice of wire sizes permits a wide range of operating voltages and power requirements. Various types of mountings further increase its adaptability. In addition to its positive control of multiple, complex circuits, a reserve of mechanical power is available for the performance of duties other than switching operations.

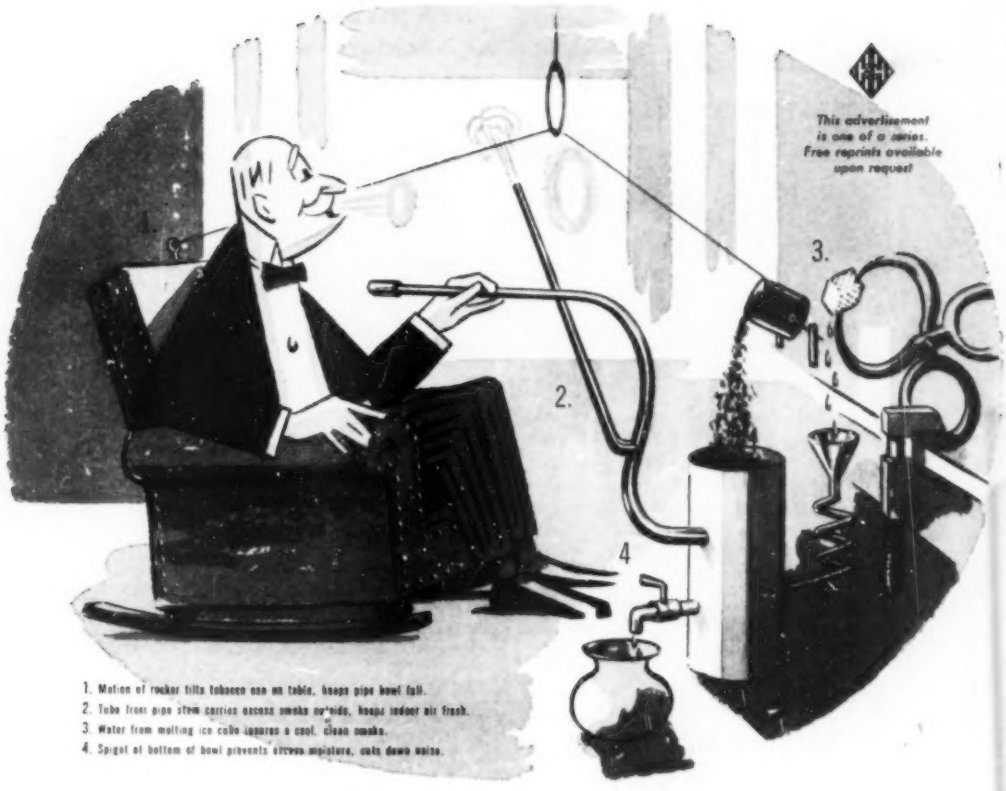
We supply to quantity users and solicit the opportunity to be of assistance in solving multiple circuit relay problems.

WRITE DIRECT TO

G. H. Leland INC.

130 WEBSTER STREET

DAYTON 2, OHIO


This advertisement is one of a series. Free reprints available upon request
3.
2.
4
1. Motion of rocker tilts tobacco can on table, keeps pipe bowl full.
2. Tube from pipe stem carries excess smoke outside, keeps indoor air fresh.
3. Water from melting ice cube assures a cool, clean smoke.
4. Spigot at bottom of bowl prevents excess moisture, cuts down noise.

There once was a man named Van Dyke
Who said, "Make me parts for this pipe;
Do the bending and flanging, annealing and all."
We said, "Van, we're delighted,
But please don't feel slighted
If D.O.'s and old jobs get first call."

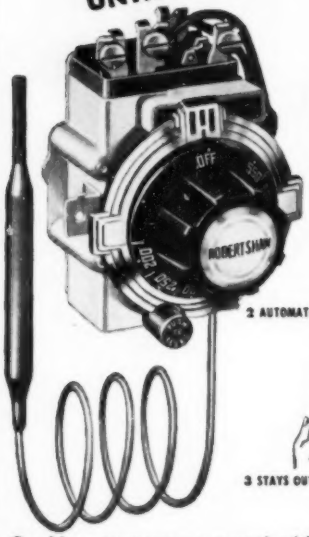
H & H makes brass or copper tubing ranging from ⅛" O.D. to and including 1½" O.D. Also brass and copper LOCKSEAM tubing for aircraft, jeep, truck and stationary engine cooling components.

Whether you wish parts for an extra fancy smoking pipe like the one pictured above, or rotating bands for twenty-millimeter shells, you can always look to H & H, a name that means the finest in brass and copper tubing. It will pay you to put your confidence in a company long noted for the care with which it meets customers' specifications for especially hard-to-fabricate tubular parts. Just like everyone else, we are steadily converting our facilities to meet increased defense and essential civilian demands. So why not write, wire or call us about your own requirements today.

H&H TUBE AND MANUFACTURING COMPANY
254 N. Forman Avenue • Detroit 17
Originators and sole makers of "Metalflo"—the economy tubing

H & H MEANS QUALITY AND SERVICE IN BRASS AND COPPER TUBING

THIS Robertshaw®
THERMOSTAT AUTOMATICALLY
CUTS OUT
AT OVER TEMPERATURE
STAYS OUT
UNTIL MANUALLY RESET



1 CYCLES AS THERMOSTAT

2 AUTOMATICALLY CUTS OUT AT SET LIMIT

3 STAYS OUT UNTIL MANUALLY RESET

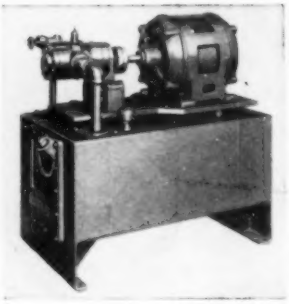
Combines temperature control with single pole switch. Current is automatically cut off and switch is locked in open position if temperature at any dial setting, through any cause, exceeds temperature range of control by approximately 7% in liquids or 12% in air. Switch remains open until closed by manual reset button. Design permits mounting control in any one of four positions. Standard size bulbs and capillary tube lengths give great flexibility to meet required heat ranges and installation needs. In direct or reverse acting models.

Write for full information.

In Home and Industry *EVERYTHING'S UNDER CONTROL*

Robertshaw
THERMOSTAT DIVISION
ROBERTSHAW-FULTON CONTROLS COMPANY
YOUNGWOOD, PENNSYLVANIA

NEW HYDRAULIC POWER UNITS conform with J.I.C. Standards



Vickers Incorporated announces new Hydraulic Power Units constructed in complete accordance with the Joint Industry Conference Hydraulics Standards for Industrial Equipment. Features include: completely sealed tank with breather air cleaner and separate filler hole having removable mesh screen and chain-attached cap; flush type oil level indicator with high and low oil positions marked. Elevated tank and separate mounting plate add to installation convenience and also allow radiation from all tank surfaces. Dished tank bottom and drain plug permit draining without spillage and cleanout holes at each end provide for complete cleaning of tank.

The new units are available in three series (T20, T30 and T60) and 10 models for electric motors from ¾ to 25 hp. Vickers single, double and two-pressure pumps are used for 1000 psi service, Vickers two-stage pumps for 2000 psi service.

For complete information, write to **Vickers Incorporated,** 1454 Oakman Blvd., Detroit 32, Mich., asking for Supplementary Sheet 12a, Catalog 5000. Adv. 4534

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WOVEN BRAKE LINING
COVERING ALL INDUSTRIAL
REQUIREMENTS FOR INTERNAL
AND EXTERNAL BRAKES

sizes 1 1/2 x 5/32" through 4 x 3/8"

LARGE CAPACITY (10,000 ft. per Day)
LONG EXPERIENCE (since 1927)
SPECIALISTS IN SHORT RUN ORDERS

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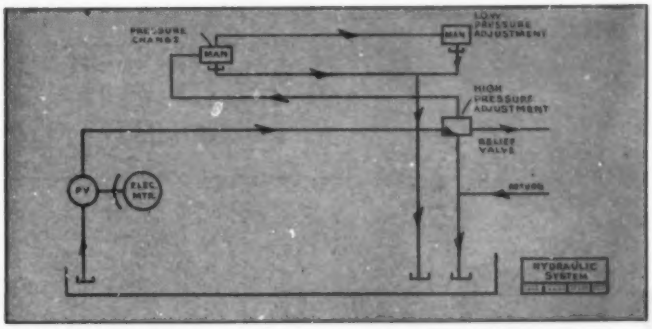
Here is *Superior* Hydraulic Tubing to Do a Better Job for You

Superior technology produces seamless steel tubing for hydraulic lines which meet fully all Joint Industry Conference hydraulic standards in all pressure ranges from 0 to above 3,000 lbs./sq. in.

All Superior production is given a 100% hydrostatic test and each lot is sampled and tested for flareability. Rigid quality control at Superior insures complete adherence to all mechanical standards.

Your Superior Distributor is ready to assist you in selecting the correct size and analysis tubing for your pressure system. *You Will Find Superior Hydraulic Tubing In Warehouse Stocks Of These Distributors.*



CHEMICAL ANALYSIS. Low carbon content is important to fabricators for ease in bending and flaring. JIC standards permit a carbon range of .08% to 18% but all Superior hydraulic tubing is held to a carbon content of .15% (max.). Superior aims for .12% maximum. Aluminum-killed tube billets insure non-aging tubing of low yield strength and unusually high elongation.

SIZE RANGE. Superior produces tubing in any size specified from .010" to ⅝" O.D.; maximum wall thickness is .125". Hydraulic tubing is available on mill order in sizes up to 1⅛" O.D. x .035" maximum wall.

LENGTHS. Available in cut, multiple or random lengths up to 28 feet. For longer lengths call your distributor warehouse for availability information.

TEMPER. Dead-soft bright annealed temper #1 is furnished for hydraulic use. Mechanical properties are 57,000 psi max. ultimate strength; 28,000/40,000 psi yield; 35/45% elongation in 2", Rockwell hardness B-63 max.

RECOMMENDED MAX. WORKING PRESSURES (psi) FOR SUPERIOR HYDRAULIC TUBING*

O.D. \ WALL	.025"	.028"	.032"	.035"	.042"	.049"	.058"	.065"	.072"	.083"	.095"	.109"	.125"
1/8"	6000	6700	7680	8430	9920	11750	x	x	x	x	x	x	x
3/16"	4000	4470	5100	5610	6750	7850	x	x	x	x	x	x	x
1/4"	2980	3350	3830	4200	5040	5890	7000	7850	x	x	x	x	x
5/16"	2410	2690	3080	3370	4040	4710	5610	6290	6950	8010	x	x	x
3/8"	1990	2240	2560	2800	3360	3920	4660	5240	5790	6660	7640	8720	9990
7/16"	1715	1920	2190	2400	2880	3360	4000	4500	4960	5720	6550	7490	8580
1/2"	1490	1675	1920	2100	2520	2940	3500	3925	4340	5000	5720	6540	7500
9/16"	1330	1490	1705	1870	2240	2620	3110	3490	3860	4450	5090	5810	6660
5/8"	1200	1340	1535	1680	2020	2350	2800	3140	3470	4000	4580	5230	6000
11/16"	1090	1220	1395	1530									
3/4"	1000	1120	1280	1400									
7/8"	860	960	1090	1200									
1"	750	840	960	1050									
1-1/8"	665	747	854	935									

*NOTE: The above values are based on an allowable fibre stress of 15,000 psi. For approximate bursting pressures, multiply these values by a factor of 3.3. The formula used for calculating the above pressures is Barlow's: $P = \frac{2St}{O.D.}$

The above sizes are available for prompt shipment from warehouse stocks or mill production. Any non-standard size you require can be readily made on mill order.

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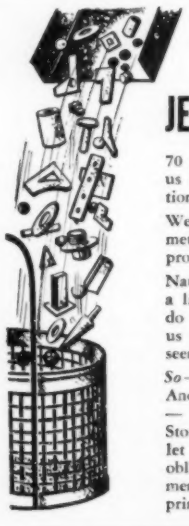

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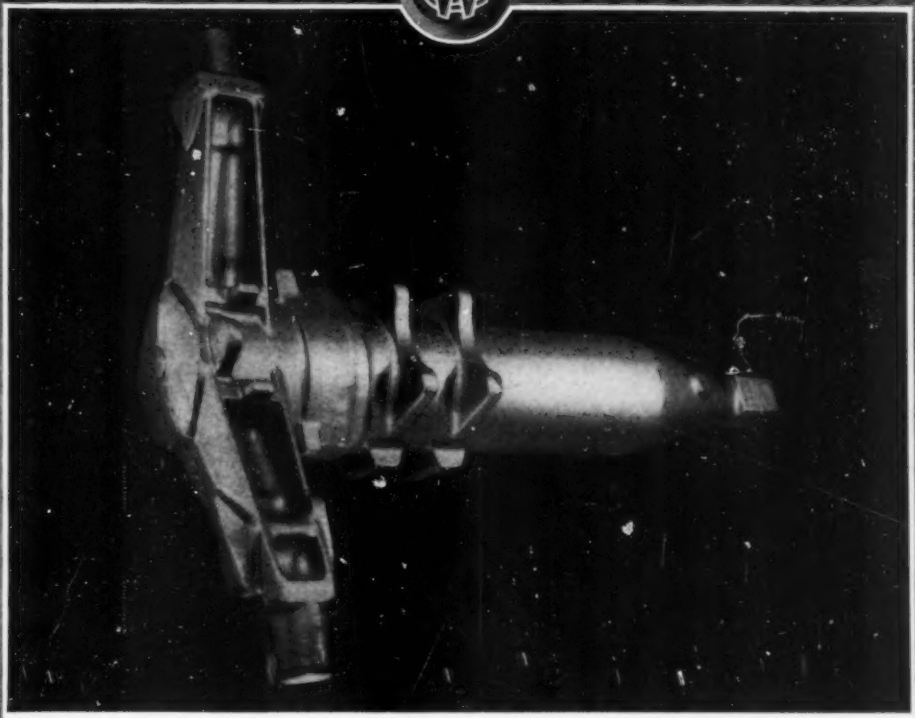

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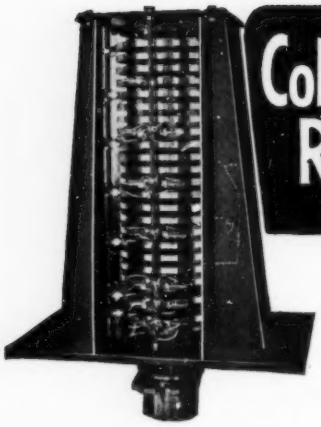

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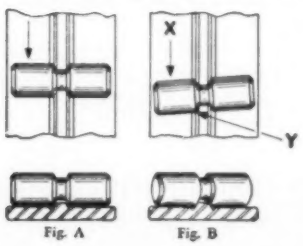

Fig. A Fig. B

A guide rail on the inside diameter of the outer race maintains roller alignment. Normally no correction is required. Should misalignment cause tendency to skew, the guide rail touches grooved rollers back into position by momentary contact at Y. X indicates direction of roller rotation.

Bulletin GR-50 lists proposed standard sizes in CT Series (interchangeable with cylindrical type dimensions) for FT Series (interchangeable with ordinary needle type dimensions). Write McGill Manufacturing Co., Inc., 201 No. Lafayette St., Valparaiso, Indiana for your copy.

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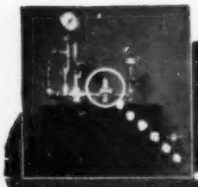

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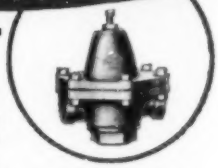

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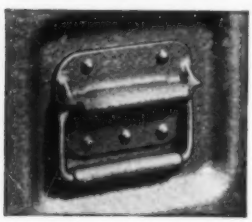

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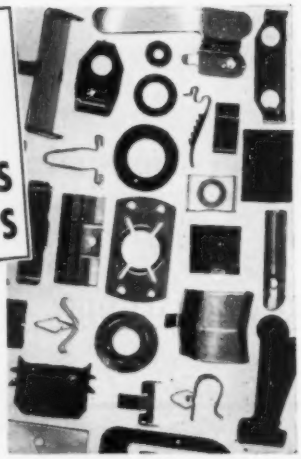

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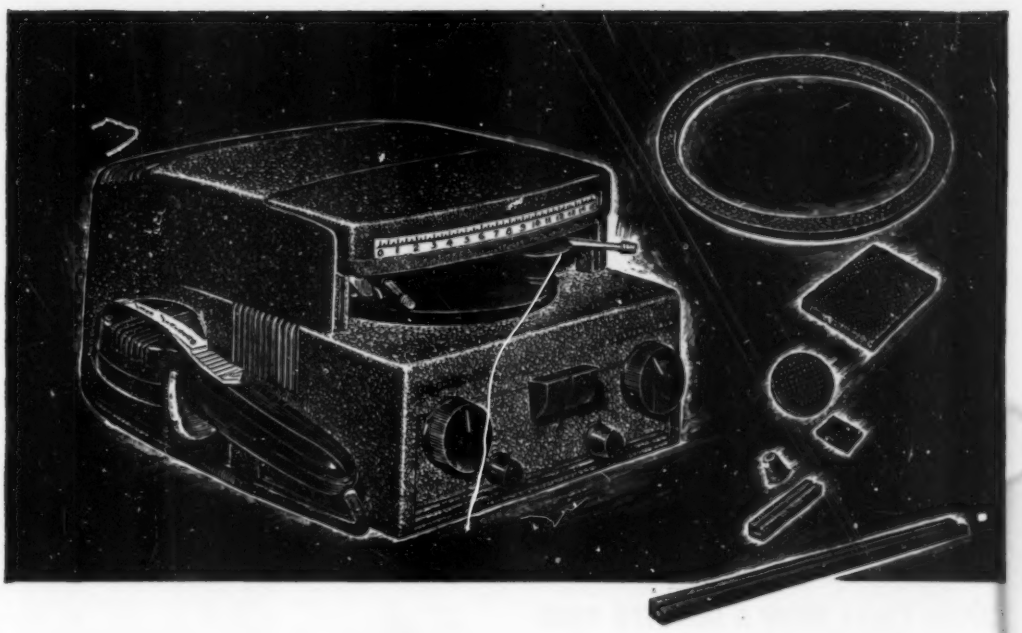

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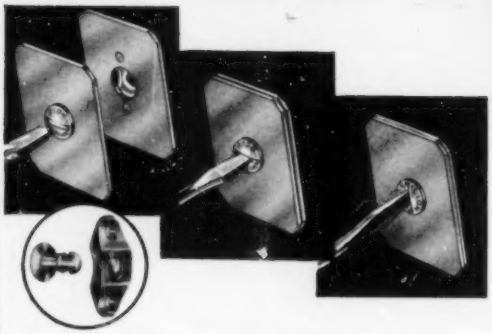

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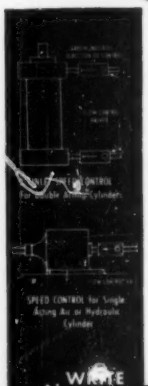

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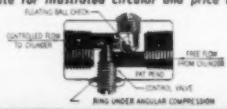

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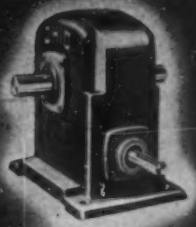

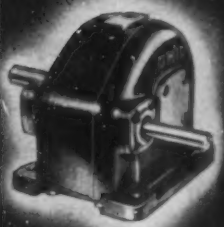
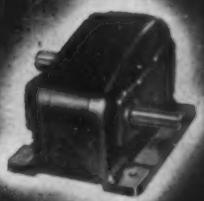

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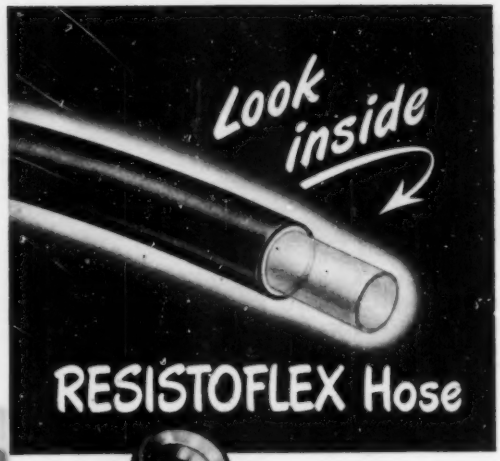

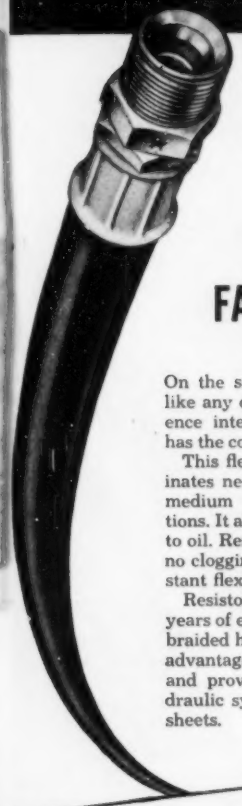

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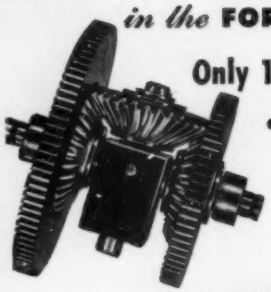

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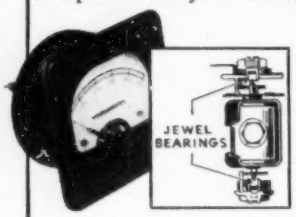

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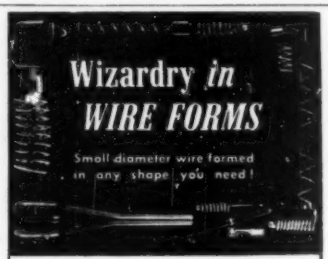

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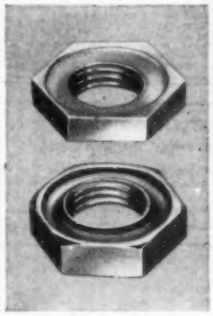

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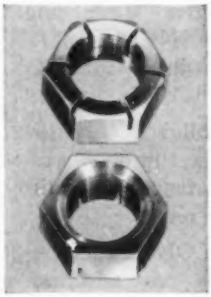

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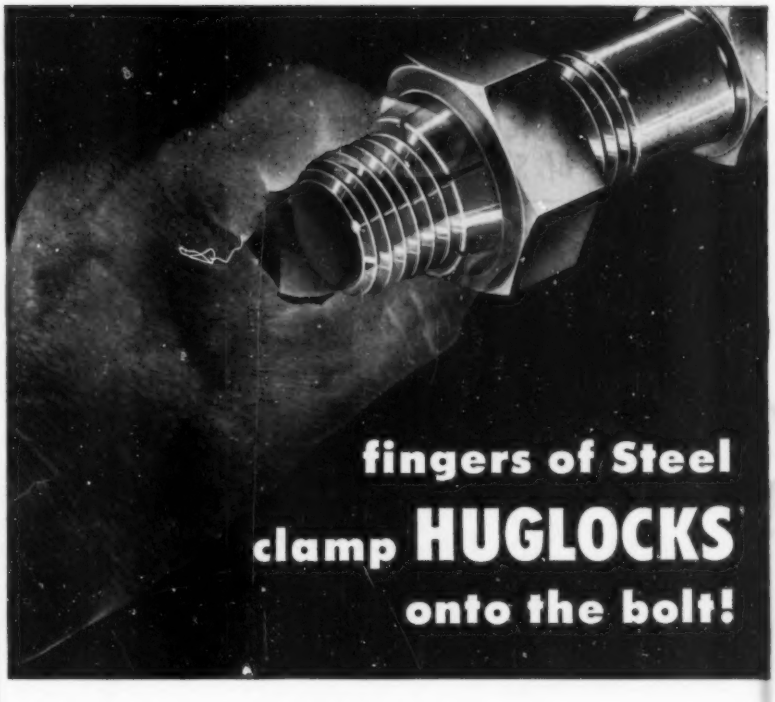

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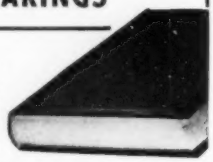

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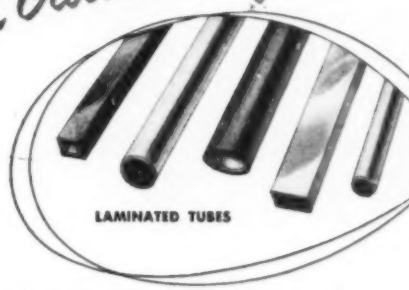

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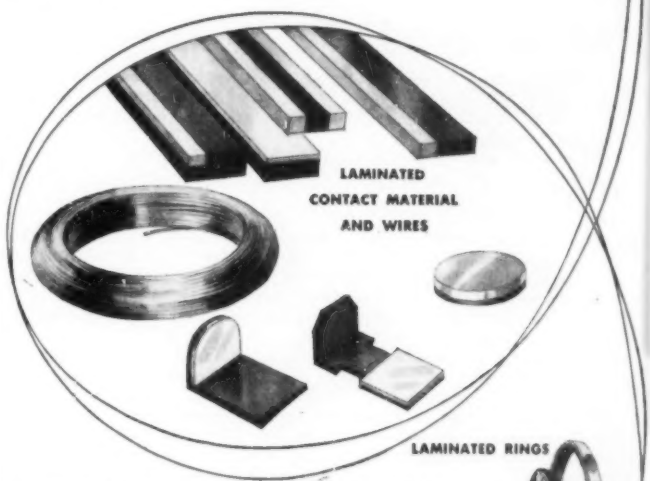

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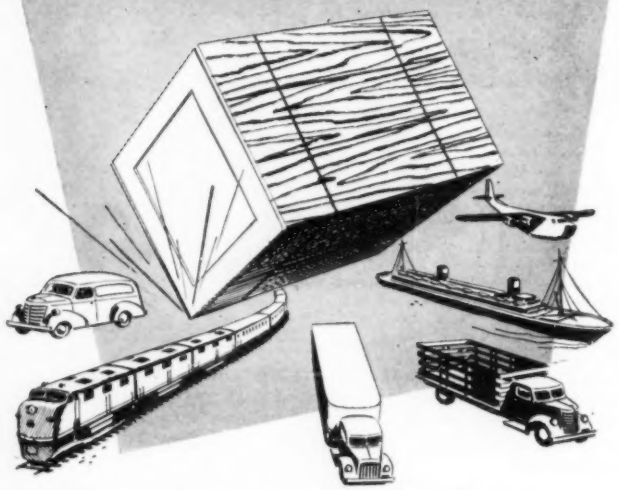

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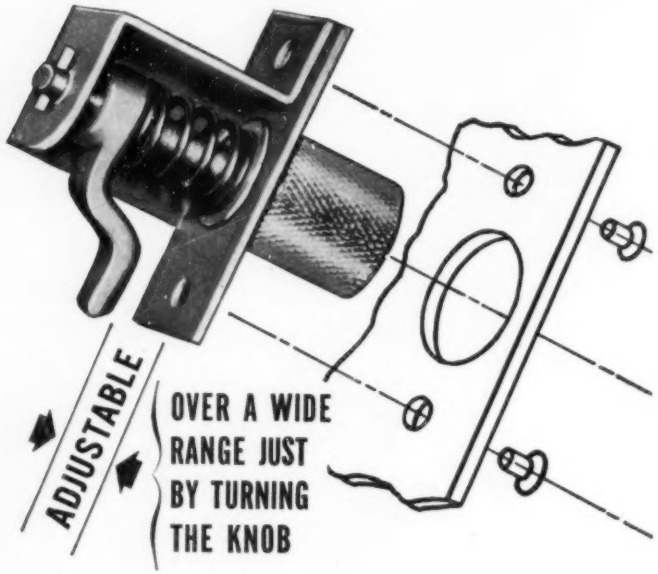

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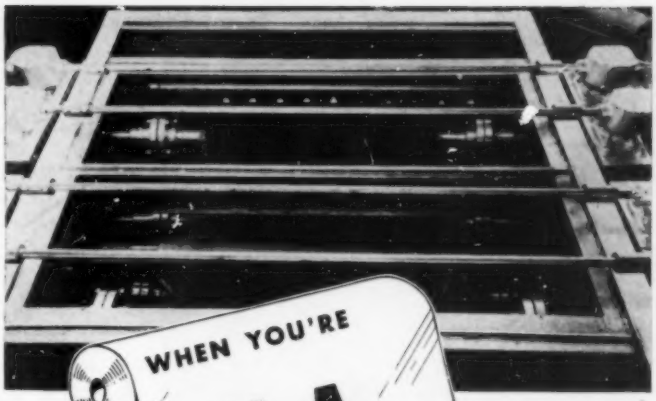


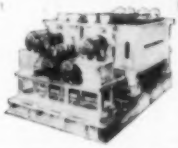
WHEN YOU'RE

"IN A PICKLE"

FULLERGRIPT BRUSHES

INSTALLED IN ROCKWELL BRUSH BOX

SCRUB CLEAN

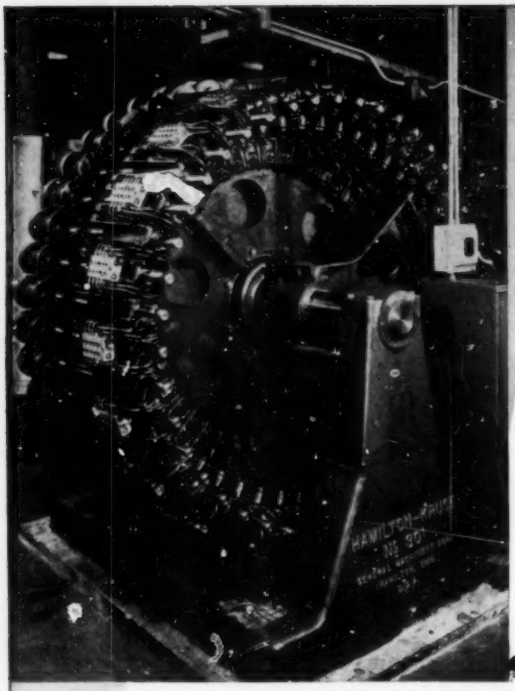


Typical of the equipment designed and built for the metal working and metal finishing industries by the W. S. Rockwell Company of Fairfield, Connecticut is the Rockwell Brush Box, used in connection with a continuous strip anneal and pickle line to produce a clean, bright finish on brass strip. Into this machine Rockwell engineers have built four power-driven Fullergript brushes. The brush material is stainless steel wire anchored in a stainless steel backing strip to withstand the corrosive effect of the pickling or cleaning solution. The brush assemblies are mounted on cone type stainless steel self-centering couples for quick and easy removal of the brushes. The same set-up can be used for dry brushing metals that have a very light film of dirt or very light oxide not requiring a pickle.

Fullergript power brushes offer similar production economies in a wide variety of industries. It will pay you to investigate the possibilities of Fullergript for your own plant. Simply write to:

THE FULLER BRUSH COMPANY

INDUSTRIAL DIVISION, 3648, MAIN ST., HARTFORD 2, CONN.



HERE'S PROOF FROM Cans Inc., of Chicago THAT *Proper Lubrication Pays Off!*

Shown in the photo is a Hamilton-Kruse vacuum tester in the plant of Cans, Inc.

221 points of lubrication are serviced by Trabon here. Prior to the installation of Trabon lubricating equipment on this machine, more than an hour per shift was required for lubrication. Even then, several points were neglected, causing expense and delay in replacing scored sleeves.

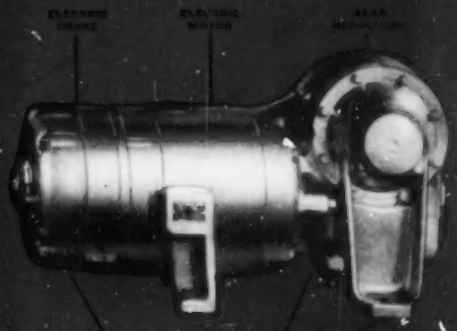
With Trabon on the job, the operation runs smoothly and economically, turning out 310 cans per minute.

Include Trabon lubricating equipment in the design of your machines. It will increase their value immeasurably. Share in Trabon's 20 years of experience in designing, manufacturing and installing oil and grease systems.

Trabon

OIL AND GREASE SYSTEMS

TRABON ENGINEERING CORPORATION
1814 East 40th Street • Cleveland 3, Ohio



The best way to power any application is to secure, in one compact unit, the RIGHT horsepower, the RIGHT shaft speed, the RIGHT features that you can use RIGHT where you want it. It's the best way and the easiest way because you purchase one unit, handle one unit in your receiving, production, and maintenance departments . . . set one unit in place and you're ready to go.

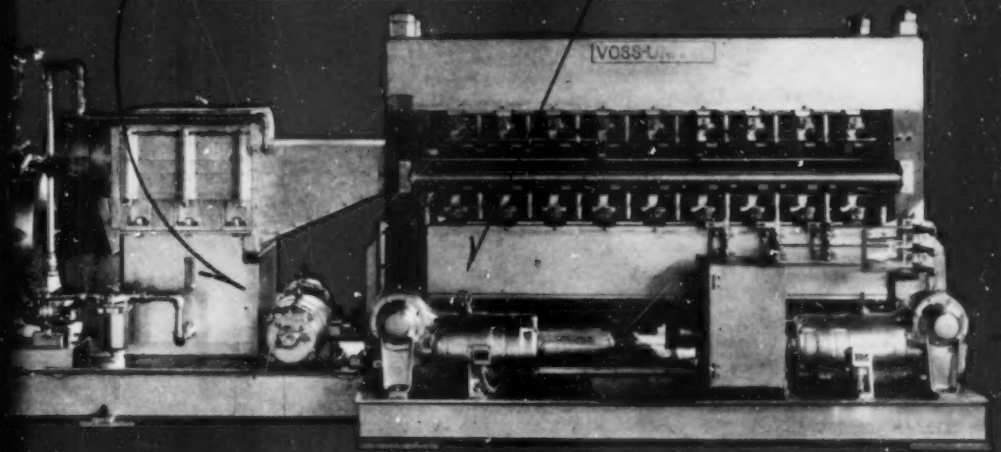
Master Motors, available in thousands and thousands of types and ratings (up to 150 HP) give you an enormous selection of integrally built power drives from which you can easily select the combination of features that's just right for each job.

the best way is the easiest way

Open, enclosed, splash proof, fan-cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 432 to 1 ratio . . . with electric brakes . . . with mechanical variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best motor drive for YOU.

Select the RIGHT power drive from Master's broad line and you can increase the saleability of your motor driven products . . . improve the economy and productivity of your plant equipment.

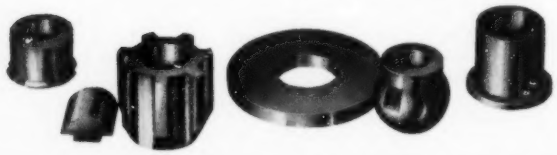
THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO



GRAMIX®

bearings carry the load in this
"HOME-UTILITY" Drill by Black and Decker

For on-the-job dependability, for long life and trouble free performance, you can't beat this ½-in. "Home-Utility" drill made by Black and Decker, the world's largest manufacturer of portable electric tools. And the big reason for this power-packed quality is found in the GRAMIX bearings that carry the load at six vital points. GRAMIX bearings maintain steady alignment of the drill shafts and absorb the thrust load under hardest operating conditions. Their porous structure is especially important in this application because they can be oil-impregnated during manufacture for self-lubrication, eliminating the need for regular oiling. GRAMIX bearings and specialty parts are precision die-pressed to tolerances within .0005". They are strong and tough, too, and their greater durability and self-lubrication features make for long life in any application. Because they require little or no machining, GRAMIX parts cost considerably less than similar machined parts. GRAMIX can help cut your costs and improve the performance of your product. For complete information write today to —



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THE UNITED STATES GRAPHITE COMPANY

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